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ESTIMATION OF PHORATE RESIDUES IN CHILLIES

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(Received 25 August 1980)

The application of phorate 10 G @ 1.5 kg ai/ha in clay loam soil resulted in the deposits of 28.70 ppm which reached 9.36, 0.95, 0.20 ppm and below detectable level at 15, 60, 75 and 90 days interval. The chilli plants grown on the soil absorbed 2.25 and 2.60 ppm of insecticide after 15 and 30 days of application which dissipated to 0.48, 0.10 ppm and below detectable level at 60, 75 and 90 days interval respectively. The fruits also absorbed the insecticide to the extent of 0.10 ppm at 50 days interval which was far below the tolerance limit and degraded completely at 75 days interval.

(Key words: Phorate residue, chilli)

INTRODUCTION

The cultivation of chillies in the state of Rajasthan is hampered by whitegrub menace in the early stage and the leaf curl disease later. The sucking pests *viz.*, aphids, *Aphis gossypii* GLOVER, thrips, *Scirtothrips dorsalis* Hood, and whiteflies, *Bemisia tabaci* (GENN.) were reported to cause leaf curl disease in chillies due to their feeding (CHERIAN, 1937; PARK & FERNANDO, 1938; CAPOOR, 1967; FERNANDO & PIERIS, 1957; PUTTARUDRIAH, 1959). Soil application of phorate G is recommended for the control of white grubs infesting chillies which also checks the sucking insects in the later stage of the crop (KUSHWAHA, 1977). Assessment of the magnitude of phorate residues in chilli plant and fruit is required from the point of view of the safety of consumers.

MATERIALS AND METHODS

About 35 days old seedlings of chilli (variety N. P. 46) were transplanted in the plots measuring 5m×3m at a distance of 0.5m from row to row and plant to plant at the vegetable farm, University of Udaipur, Udaipur during *kharif*, 1978. After 5 days of transplanting, phorate 10G was side dressed @ 1.5kg ai/ha. The samples of soil (upto 10 cm depth) and plants were collected at regular intervals until the residues reached below detectable level.

The insecticide was extracted from soil samples in distilled chloroform as solvent @ 4 ml/g by tumbling on motorised shaker for 30 minutes. The supernatent extract was filtered through a Whatman filter paper No 1 and collected in a reagent bottle. The plant and fruit samples were chopped and macerated in the Warring blender using distilled solvent @ 3 ml/g. The extract was filtered under pressure through a scintered funnel containing a thin layer of hyflo-supercel and anhydrous sodium sulfate. There was no need of cleanup of soil extract whereas the extracts of plant and fruit samples were cleaned up according to the procedure of PAREEK *et al.* (1978). The residues of phorate were estimated using the method of GETZ & WATT (1964). The recoveries of phorate from fortified samples of soil, plant and fruits with this method ranged between 90–95 per cent.

RESULTS AND DISCUSSION

The soil application of phorate in clay loam @ 1.5 kg ai/ha resulted in the

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TABLE I. Residues of phorate in soil and chilli plant.

Days after treatment	Residue (pp)* Soil (% reduction)	Whole plant (% absorption)	Fruit (% absorption)
0	28.70	—	—
15	9.36(67.38)	2.25(7.81)	—
30	7.55(73.69)	2.60(9.06)	—
45	3.50(87.80)	1.70(5.92)	—
60	0.95(96.69)	0.48(1.67)	0.10(0.35)
75	0.20(99.30)	0.10(0.35)	BDL(0.0)
90	BDL(100.00)	BDL(0.0)	—

*— Average of three replicates BDL— Below detectable level.

initial deposits of 28.70 ppm (Table 1). The dissipation of residues from the soil to the extent of 67.38, 96.69 und 100 per cent after 15, 60 and 90 days respectively clearly exhibit its rapid loss. The residues detected 75 days after the application was 0.20 ppm corresponding to 99.30 per cent dissipation. Similar rapid losses were also reported from the soil (SINGH & GULATI, 1971; PAREEK *et al.*, 1978; KUMAR, 1979). The absorption by the chilli plants grown on the treated soil may be the cause of such losses besides several other factors. The plants absorbed 2.25 and 2.60 ppm of residues after 15 and 30 days of application which corresponded to about 7.8 and 9.06 per cent of the initial deposits. The residues in plants estimated at further interval of 45, 60 and 75 days were quite low and decreased with the passage of time. Such low levels of residues may be due to the degradation of the accumulated residues in the plants and the presence of low levels of residues in the soil itself where from the residues could be absorbed. It is presumed that the translocation of the residues in the fruits if borne on the plant would be also low. The data on the residues in fruits confirm the assumption. After 90 days, however, the residues were below detectable level in plants. At this stage the soil residues of phorate were also below detectable level.

In the plants grown on the treated soil, the fruit bearing though started earlier than 60 days but the fruit samples drawn after 60 days found to contain 0.10 ppm of residues and after 75 days below detectable level. The fruits thus contained residues below tolerance limit of 0.5 ppm (ANONYMOUS, 1970).

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EFFICACY OF *BACILLUS THURINGIENSIS* BER. FOR THE CONTROL OF LEPIDOPTEROUS PESTS OF VEGETABLE CROPS[1]

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Formulations of *Bacillus thuringiensis* Ber. were evaluated for the control of major lepidopterous pests of okra, cabbage, egg plant and trailing beans in the field trials during 1974-1978. On okra, weekly sprays of dipel at 0.5 kg/ha reduced fruit infestations of *Earias vittella* Fabr. Spraying Dipel in a 10 day schedule during fruiting period at 0.5 kg/ha brought about the suppression of tomato fruit borer, *Heliothis armigera* Hub. to the same extent as fortnightly applications of monocrotophos (0.5 kg/ha). Weekly sprays of dipel (at 0.5 kg/ha) were quite effective in controlling the diamond back moth (*Plutella xylostella* L.) on cabbage, with the degree of efficacy comparable to that of fortnightly sprays of methamidophos and quinalphos (0.5 kg a.i/ha). Better control was achieved when dipel was sprayed in combination with chlordimeform (both at 0.25 kg/ha). Populations of *Apanteles plutellae* Kurdj. were not affected by dipel sprays. *Crocidolomia binotalis* Zell. was also controlled on cabbage effectively by weekly dipel sprays. Dipel was ineffective against shoot and fruit borer, *Leucinodes orbonalis* Guen. on egg plant and pod borers, *Adisura atkinsoni* Moore on trailing beans.

INTRODUCTION

Of late, there has been a growing emphasis on the use of less persistent, specific and safe methods for the control of crop pests. There is a fear of contamination of food stuffs with poisonous residues and possible ill effects on the ecosystem due to persistent and broad spectrum pesticides. *Bacillus thuringiensis* BER. qualifies to be an ideal alternative. Its efficacy in controlling some major insect pests of crops particularly those belonging to Lepidoptera has been amply demonstrated by FALCON (1971): CREIGHTON & MCFADDEN (1975): TAYLOR (1974): ONGOREN *et al.* (1977) and CHANG (1972). It is extensively utilised in the U S A, U S S R and many other European countries. Some efforts have been initiated for its use in our country. An initial step in this direction would be to evaluate its bioefficacy in controlling the major pests of crops in this country. The present communication deals with the results of field trials conducted during 1974—1978 at the Indian Institute of Horticultural Research, Hessaraghatta to evaluate two formulations of *B. thuringiensis* to control vegetable pests.

MATERIALS AND METHODS

Two formulations of *B. thuringiensis* viz. cajrab and dipel were evaluated. These were applied as high volume sprays. An emulsifier, sandovit (a product of Sandoz) at 0.05% was added to the spray fluid. In an okra experiment, (C. V. Pusa Sawani) conducted during February-May 1974, dipel was sprayed at 0.5 kg/ha thrice

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at weekly intervals during fruiting season. On tomato (C. V. Pusa Ruby) dipel dosages ranging from 0.25 to 1.00 kg/ha were applied at 7 and 10 day intervals during the fruiting season. Similarly on egg plant (var. Pusa Purple Cluster) and trailing beans (var. Pusa Early Prolific) dipel at 0.5 kg/ha was sprayed at weekly intervals. In all these crops the criterion for evaluation was the per cent borer fruits/pods. This was calculated on the basis of cumulative data of all pickings made during the crop season. On cabbage (var. Golden Acre) dipel (0.5 kg/ha) and cajrab (5 kg/ha) were sprayed at weekly intervals from the time of pest appearance and the result was assessed on the number of larvae recorded from 10 randomly selected plants from each plot on different days after spraying. In case of parasite, the number of pupal cocoons formed the basis of their counts.

RESULTS AND DISCUSSION

Okra

Dipel sprays (0.5 kg/ha) effectively controlled okra fruit borer, *Earias vittella* FABR. recording 14.98% fruit borer damage as against 8.06 and 24.22% in carbaryl and untreated check respectively (Table 1). From Nigeria, TAYLOR (1974) also reported its efficacy to control *Earias* spp. and other lepidopterous pests like *Sylepta leona*, *Heliothis armigera* and *Spodoptera littoralis* on okra.

Tomato

In a trial conducted during January-May, 1974, the percentage of fruits damaged by *H. armigera* in dipel treated plot (0.5 kg/ha) was significantly lower (7.41%) than in the untreated check (21.30%) (Table 2). The degree of pest control achieved was comparable to that of carbaryl sprays at 2 kg ai/ha which recorded 3.67% damage. In a 1977 trial (January—May) dipel even at 0.25 kg/ha with 10 day spraying frequency offered protection equal to dipel 1 kg/ha. However, the efficacy of dipel at 0.5 kg/ha with 10 day frequency was only comparable to monocrotophos, 0.5 kg ai/ha spray. Effectiveness of dipel in controlling this pest on tomato was also reported by ONGOREN *et al.* (1977) from Turkey and of Thuricide against *Heliothis* spp. in Texas by HARDING (1971).

Cabbage

On cabbage cajrab (5 kg/ha) was evaluated in the trials conducted in 1975 (July—September) and in 1975—1976 (November—February). It was found ineffective (Table 3) in controlling diamondback moth, *Plutella xylostella* L. and leaf webber, *Crocidolomia binotalis* ZELL. In two

TABLE 1. Control of *Earias vittella* on okra (February—May, 1974)

Treatment	Dosage kg ai/ha	Per cent borer infested fruits
1. Carbaryl	1.0	8.06 b
2. Monocrotophos	0.5	3.99 a
3. Dipel	0.5	14.98 c
4. Untreated check	—	24.22 d

Total treatments in the trial were 12. Percentages transformed to arc sin values for statistical analysis. Values followed by the same letter do not differ significantly at 0.05 probability level. Treatments 1 and 2 received fortnightly sprays while treatment 3 received sprays at weekly intervals.

TABLE 2. Efficacy of dipel in the control of tomato fruit borer (*Heliothis armigera* HUB.)

Treatments	Dosage kg ai/ha	Spraying frequency in days	Per cent fruit borer infestation during		
			January—May 1974	October 1976—February 1977	January—May 1977
1. Dipel	0.25	7	—	—	8.97 b
2. Dipel	0.25	10	—	—	8.31 b
3. Dipel	0.5	7	7.41 a	1.79 a	6.86 a
4. Dipel	0.5	10	—	2.29 b	4.49 a
5. Dipel	1.0	7	—	1.39 a	5.39 a
6. Dipel	1.0	10	—	2.67 b	6.57 a
7. Monocrotophos (Nuvacron 40 E C)	0.5	7	—	—	7.04 a
8. Monocrotophos (Nuvacron 40 E C)	0.5	14	—	0.63 a	4.60 a
9. Malathion (Cythion 50 E C)	1.0	14	—	—	4.63 a
10. Carbaryl (Sevin 50 W P)	2.0	14	3.67 b	—	—
11. Untreated check		—	21.30 a	4.10 b	18.78 c

Total treatments in the first trial were 11. Data transformed to arc sin values for statistical analysis. Values followed by the same letter do not differ significantly at 0.05 probability level. —Indicates that the treatments were not evaluated in the respective trials. Dosage mentioned for dipel is based on formulated material.

TABLE 3. Efficacy of cajrab in the control of cabbage pests.

Treatments	Dosage kg ai/ha	Larval population/10 plants on different days after spray				
		2 days	4 days	7 days	10 days	14 days
		Plutella xylostella (July—September, 1975)*				
Cajrab	5.0	3 b	2 b	32 b	22 b	15 b
Quinalphos (Ekalux 25 E C)	0.5	0 a	0 a	1 a	1 a	3 a
Untreated check	—	6 b	13 b	56 b	27 b	29 b
		Crocidolomia binotalis (November 1975—February 1976)**				
Cajrab	5.0	25 b	9 b	10 b	10 a	10 a
Quinalphos (Ekalux 25 E C)	0.5	1 a	1 a	1 a	0 a	4 a
Untreated check	—	12 b	11 b	14 b	9 a	24 a

* Total treatments in the trial were 15. ** Total treatments in the trial were 20. Data transformed to logarithms for satistical analysis. Values followed by the same letters do not differ significantly at 0.05 probability level. Dosage mentioned for cajrab is based on formulated material.

TABLE 4. Control of diamond back moth on cabbage (July—September 1976).

Insecticides	Dosage kg ai/ha	Larval count of *P. xylostella*/ 10 plants on different days after second spray		
		2	10	14
1. Quinalphos (Ekalux 25 E C)	0.25	0 a	0 a	2 ab
2. Quinalphos (Ekalux 25 E C)	0.5	2 a	0 a	0 a
3. Chlorpyriphos (Dursban 20 E C)	0.25	0 a	2 a	7 bcd
4. Chlorpyriphos (Dursban 20 E C)	0.5	0 a	3 bc	10 cd
5. Chlordimeform* (Galecron 40 E C)+ Dipel	0.25 0.25	0 a	0 a	0 a
6. Dipel	0.5	6 b	1 ab	1 ab
7. Endosulfan (Thiodan 35 E C)	0.7	2 b	0 a	2 ab
8. Methamidophos (Tamaron 40 S C)	0.5	1 ab	1 a	9 bcd
9. Quinalphos** Malathion schedule	0.5	0 a	0 a	1 ab
10. Malathion (Cythion 50 E C)	1.0	5 b	7 cd	13 bcd
11. Garlic oil	0.5%	16 b	6 cd	6 bcd
12. Control		30 c	8 d	24 d

Treatment 2 and 9 are same at the second spray. Data transformed to logarithms for statistical analysis. Values followed by the same letters are not significantly different at 0.05 probability level. Dosage mentioned for *B. thuringiensis* (Dipel) is based on formulated material.
** 3 sprays of quinalphos followed by one spray of malathion.

separate trials conducted during 1976 and 1977 (July—September) effective control of *P. xylostella* was achieved with dipel. In 1976 trials, dipel (0.5 kg/ha) sprays at weekly interval were found to give equal control of the pest as fortnightly sprays of the most effective synthetic insecticide, quinalphos. Sprays containing a mixture of dipel and chlordimeform (0.25 kg/ha each) were found superior to dipel alone at 0.5 kg/ha (Table 4). In 1977 trial the performance of dipel at 0.25 kg/ha in weekly sprays was comparable to that at 0.5 kg and also to fortnightly sprays of quinalphos. Further, when dipel was sprayed in combination with a selective aphicide, ethiofencarb (both at 0.25 kg/ha) its efficacy was unaltered (Table 5). Populations of *Apanteles plutellae,* which constitutes one of the key mortality factors of the pest, were not affected by dipel sprays (Table 6). Ratio of the parasite to pest populations was around 1:3 in dipel sprays and its combinations. This ratio in untreated check was also 1:3 as against a ratio of 1:8 in endosulphan and quinalphos treatments. CREIGHTON & MCFADDEN (1975), KENNEDY&OATMAN (1976) from U S A, CHANG (1972) from Taiwan, ONGOREN *et al.* (1977) from Turkey, HO & NG (1970) from Malaysia and ANAIS (1972) from the West Indies also reported the efficacy of *B. thuringiensis* formulations in the control of *P. xylostella.* Dipel (0.5 kg/ha) weekly sprays effectively controlled the leaf webber, *C. binotalis* on cabbage in trials conducted in November 1977 and February

TABLE 5. Control of diamond back moth on cabbage (July—September, 1977).

Treatments	Dosage kg ai/ha	Average number of larvae/ 10 plants on different days after First spray		Second spray			Third spray	
		2 days	4 days	2 days	4 days	7 days	2 days	7 days
1. Carbofuran (Furadan 3 G)	1.0	11 b	6 b	5 b	2 a	2 a	4 b	3 b
2. Carbofuran+ Dipel	1.0 0.5	6 b	1 a	1 a	1 a	0 a	0 a	1 a
3. Dipel	0.5	9 b	1 a	1 a	1 a	1 a	0 a	2 a
4. Dipel	0.5	13 c	2 a	2 a	1 a	2 a	0 a	1 a
5. Ethiofencarb (Croneton 50 E C)+ Dipel	0.25 0.25	3 a	1 a	1 a	0 a	1 a	0 a	0 a
6. Endosulfan (Thiodan 35 E C)	0.7	2 a	6 b	3 a	4 b	13 b	8 bc	7 b
7. Quinalphos (Ekalux 25 E C)	0.5	3 a	2 a	1 a	6 b	4 a	3 a	1 a
8. Uuntreated check		11 c	20 c	26 c	8 b	20 b	17 c	39 c

Data transformed to logarithms for statistical analysis. Values followed by the same letter do not differ significantly at 0.05 probability level. Treatments 2 to 5 received weekly sprays while treatments 6 and 7 received sprays fortnightly at intervals. Soil application of carbofuran was done at the time of transplanting.

TABLE 6. Effect microbial and chemical pesticides on the populations of *Plutella* and *Apanteles* on cabbage (July—Sept. 1977).

Treatments	Dosage kg ai/ha	Mean incidence on 10 plants		Parasite to pest ratio
		Apanteles	*Plutella*	
1. Carbofuran (Furadan 3 G)	1.0	22	58	1:2.6
2. Carbofuran+Dipel	1.0	4	9	1:2.2
3. Dipel	0.5	6	23	1:3.8
4. Dipel	0.25	11	27	1:2.5
5. Dipel + Ethiofencarb (Croneton 50 E C)	0.25 0.25	5	16	1:3.2
6. Endosulfan (Thiodan 35 E C)	0.7	18	142	1:7.9
7. Quinalphos (Ekalux 15 E C)	0.5	7	57	1:8.1
8. Untreated check	—	89	262	1:3.0

Treatments 2 to 5 received weekly sprays while treatments 6 and 7 received sprays at fortnightly intervals. Soil application of carbofuran was done at the time of transplanting.

TABLE 7. Evaluation of dipel for the control of egg plant fruit borer, *Leucinodes orbonalis* GUEN.

Treatment	Percent concentration in spray fluid	Percent borer infested fruits
	*August—December, 1977**	
1. Carbaryl	0.15	8.3 a
2. Cajrab	0.50	20.6 b
3. Untreated check	—	30.7 b
	*July—November, 1978***	
1. Quinalphos	0.05	23.8 a
2. Dipel	0.05	32.7 b
3. Untreated check	—	36.3 b

* Total treatments in the trial were 9. ** Total treatments in the trial were 11. Percentages transformed to arc sin values for statistical analysis. Values followed by the same letter do not differ significantly at 0.05 probability level. Trertment 1 in both the trials received fortnightly sprays while treatment 2 received sprays at weekly intervals.

TABLE 8. Efficacy of Dipel for the control of *Dolichos* pod borer, *Adisura atkinsoni* MOORE (July 1977—February, 1978).

Treatment	Percent concentration in spray fluid	Percent infested
1. Dipel	0.05	43.76 b
2. Monocrotophos	0.05	21.00 a
3. Fenvalerate	0.025	8.57 a
4. Untreated check	—	45.30 b

Total No. of treatments were 17. Percentages transformed to arc sin values for statistical analysis. Values followed by the same letter do not differ significantly at 0.05 probability level. Treatment 1 received weekly sprays while treatments 2 and 3 were sprayed at fortnightly intervals.

1978. Average incidence of larvae on 10 plants over 10 observations in dipel, quinalphos and untreated check were 1, 2 and 16 respectively. CHANG (1972) also achieved control of this pest by dipel sprays in Taiwan. Formulations of *B. thuringiensis* were also found effective against other important cabbage pests like *pieris brassicae* L. (VERMA *et al.* 1974) *Trichoplusia ni* HUB. (CREIGHTON & MCFADDEN; 1975; CHALFANT *et al.* 1973; RAMIREZ *et al.* 1973, JAQUES, 1979) and *Spodoptera littoralis* (CHANG, 1972).

Egg Plant

In an insect control trial conducted

during August—December 1977 per cent fruit borer *(Leucinodes orbonalis* GUEN) infestation was of the order of 20.6 in weekly cajrab spray (0.5%) as against 30.7 in untreated check and 8.3 in carbaryl treatment. In a similar trial during 1977 borer infested fruits in dipel (0.05%) quinalphos and untreated check accounted for 32.7, 23.8 and 36.3% respectively (Table 7). Thus both the formulations of *B. thuringiensis* were found ineffective in controlling the fruit borer.

Trailing Beans (Dolichos lablab var. typicus)

In a field trial carried out in July 1977—February 1978 dipel sprays (0.05%) were found ineffective in controlling the pod borer, *Adisura atkinsoni* MOORE. Pod borer infestation in dipel (0.05%), fenvalerate (0.025%) and untreated check were 43.76, 8.57 and 45.30% respectively (Table 8).

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AN ARTIFICIAL DIET FOR REARING *CROCIDOLOMIA BINOTALIS* ZELLER AND *HELLULA UNDALIS* FB. (LEPIDOPTERA : PYRALIDAE), TWO MAJOR PESTS OF COLE CROPS IN INDIA

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An artificial diet is described for laboratory rearing of *Crocidolomia binotalis* and *Hellula undalis* Fb., two major pyralid pests of cole crops in India. Larvae fed on the diet produced healthy moths with normal fertility and fecundity.

(Key words: artificial diet *Crocidolomia binotalis, Hellula undalis,* cole crops).

INTRODUCTION

A prime pre-requisite for continuous laboratory propagation of natural enemies of any insect pest is the availability of the host insect all the year round. Also, it should be possible to maintain a disease-free culture of the host insect, with minimum manual labour involved in the culture maintenance work. This is best accomplished by developing an artificial or semi-synthetic diet on which the host insect can be reared from the time it hatches until pupation without need for replenishment of the food in the intervening period. SINGH (1977) has compiled artificial diets developed for rearing a variety of insects by different workers, but neither this review nor other literature contain information on diets for the two insects involved in the present study.

Under the All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds, it is proposed to introduce exotic natural enemies of various pests and also wherever necessary or possible, to augment populations of indigenous natural enemies for improved biological control. Since two of the pests which come within the purview of this project are *Crocidolomia binotalis* ZELLER and *Hellula undalis* FB., both very destructive pests of cole crops in India, particularly of cabbage, it was decided to develop an artificial diet for rearing these two pests so that rearing of natural enemies is facilitated. *C. binotalis* is widely distributed, occurring in many countries in Asia and Africa as well as in Australia where it is confined to eastern Queensland (ANON, 1979).

MATERIALS AND METHODS

A diet similar to that used by BERGER (1963) and BIEVER & BOLDT (1971) was used, with a few modifications. The camposition of the diet is given in Table 1.

This diet differs from BERGER'S (1963) diet in the following respects: a) Cellulose powder was used in place of Alphacel. b) Multivitaplex forte (product of Dumex Pfizer Limited) was used instead of vitamin solution. c) As the

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TABLE 1. Ingredients used for preparation of artificial diet for *Crocidolomia binotalis and Hellula undalis.*

Water	140 ml
KOH 22.5%	1.8 ml
Casein (vitamin-free)	12.6 g
Wesson's salt mixture	3.6 g
Sucrose	12.6 g
Formaldehyde 10%	1.3 ml
15% methyl p-hydroxy benzoate in 95% ethyl alcohol	3.6 ml
Choline chloride	3.6 ml
Wheat germ	10.8 g
Cellulose powder	1.8 8
Vitamins (Multivitaplex forte)	0.5 g
Agar dissolved in 220 ml. of boiling water	9.0 g
Ascorbic acid	1.4 g
Tetracycline	100 mg
Sorbic acid	0.5 g
Linseed oil	2.0 ml
Dried cabbage leaf powder	5.0 g in 50 ml water at 50°C

diet tended to dry out faster under our laboratory conditions, 50 ml additional distilled water was added. d) Tetracycline was used instead of aureomycin as the latter was not readily available. e) Since growth of mould is more common in our tropical conditions, sorbic acid was added to the diet. f) The addition of linseed oil greatly improved wing formation in adults. g) Dried cabbage leaf powder was used in place of rape leaf powder. Substitution with cauliflower or knol-kohl leaf powder did not make any difference. The leaf powder was mixed with 50 ml water at 50°C, left undisturbed for 10 minutes and then added to the diet. h) As ferric phosphate was not available locally, this salt was excluded from the Wesson's salt mixture. Its absence did not affect growth or development in this case

Moths of both species were released in separate plastic jars (15 cm high and 12 cm diameter) with screw top lids for egg laying. The centres of the lids were cut out and replaced with fine wire-gauze (100 mesh). As eggs were not laid on paper strips, cabbage leaves sterilised by rinsing in 0.02% solution of potassium permangenate for 5 minutes were provided in the cages. Eggs were laid readily on such leaves. The eggs were again sterilised in 0.01% sodium hypochlorite before hatching.

The diet was prepared as follows: All ingredients except the agar solution, Mutlivitaplex, ascorbic acid, sorbic acid, tetracycline and formaldehyde were placed in the blender bowl and mixed thoroughly. The hot agar solution (60°C) was then added to the mixture, followed by addition of the other five ingredients mentioned above, these being added after the mixture was cooled slightly. The diet was then quickly dispensed into 7.5 cm × 2.5 cm sterilised vials upto a depth of 2.5 cm and allowed to cool and solidify.

Three neonate larvae of *C. binotalis* and five of *H. undalis* were transferred into each vial and the latter was plugged with sterile cotton wool.

RESULTS

The results of rearing *C. binotalis* and *H. undalis* on artificial diet are summarised

TABLE 2. Comparative studies on *C. binotalis* and *H. undalis* when reared on artificial and natural diets.

		C. binotalis		*Ht undalis*	
		On artificial diet	On natural diet	On artificial diet	On natural diet
Ave. Larval period	Range:	20.75 days (18—27 days)	18.85 days (17—19 days)	22 days (17—33 days)	18 days (17—19 days)
Ave. Pupal period	Range:	8.05 days (5—10 days)	9.45 days (7—12 days)	9.3 days (6—16 days)	6 days (5—7 days)
Ave. Pupal weight		47.25 mg (37—67 mg)	31.85 mg (18—44 mg)	19.78 mg (13—27 mg)	16.0 mg (13—19 mg)
Fecundity of *		168.33 eggs	155.67 eggs	76.4 eggs	90.8 eggs
Sex ratio		1:1 (based on 22 individuals)	*	1:1 (based on 36 individuals)	*

* Information not available.

in Table 2. With survival being as high as 91 and 84 per cent respectively, the diet may be considered to be quite satisfactory. Single larvae of *C. binotalis* and *H. undalis* consumed 1.6 and 1.8 of diet, respectively.

A comparison was made between larval development, pupal period and pupal weight when the two test insects were reared on artificial diet vs. natural food (cabbage leaves). As the number of experimental individuals particularly on natural diet, was small, Student's 't' test was applied for statistical analysis. The differences were significant at 5% level in all cases, except with regard to larval period of *H. undalis* where it was non-significant. Fecundity could not be statistically analysed as the number of individuals was small, however it appeared to compare favourably.

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CHEMICAL CONTROL OF RED HAIRY CATERPILLAR INFESTING COTTON

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The maximum mortality was recorded in caterpillars hit by spraying material and fed on treated food as well as on untreated food. Monocrotophos gave the maximum mortality, 99.2 and 97.0 per cent respectively, in these two conditions. There was comparatively low mortality in untreated larvae feeding on treated food. The mortality on the day of spraying varied from 46.7—52.3 per cent in treated plots. The mortality among the treated larvae feeding on 2 and 4 days old spray deposit was 30.4—44.4 and 12.8—39.9 per cent, respectively. So monocrotophos was the best followed by phenthoate, quinalphos and endosulfan. The least effective insecticide was DDT.

(Key words: red hairy caterpillar, cotton, chemical control)

INTRODUCTION

The red hairy caterpillar, *Amsacta moorei* BUTLER is a sporadic pest of cotton in the Punjab. It is active from end of June to the middle of October and during the period 70—80 per cent caterpillars pass through one brood while remaining caterpillars may complete 2—3 broods (CHAUDHARY *et al.*, 1970). This pest appeared in serious form in some fields under American cotton during 1977. An experiment was conducted to see how far the promising insecticides for control of cotton pests are effective against this pest.

MATERIALS AND METHODS

Endosulfan, DDT, carbaryl, fenitrothion, quinalphos, phenthoate, phosalone and monocrotophos are recommended for the control of cotton pests (ANONYMOUS, 1978) in the Punjab, were tested against 4th and 5th stage caterpillars of *Amsacta moorei*.

The plots of American cotton var. *F* 414 measuring 50 × 20 m each were sprayed with different insecticides (Table 1). Large number of caterpillars were collected from the centre of plot within half an hour of spraying. These were divided in 6 batches of 15 each. Three batches representing 3 replications were given sprayed leaves of cotton as food, while the other three batches were given untreated leaves as food. Mortality among these larvae was recorded after 48 hours. All moribund larvae being taken as dead. Residual effect of these insecticides on migrating larvae up to 4 days after spraying was done by feeding the untreated larvae on treated leaves of cotton. For this purpose, large number of larvae (4th and 5th stage) were collected from the untreated crop in the adjoining fields. These were divided in 3 batches of 15 each. They were fed on sprayed cotton leaves having 0, 2 and 4 days old deposits of the insecticides. Mortality among them was recorded as above, after 48 hours.

RESULTS AND DISCUSSION

Mortality among the treated larvae feeding on treated food, treated larvae feeding on untreated food and untreated larvae feeding on treated food is given in Table 1. It was found that maximum mortality occurred in those larvae which were hit by spray material and were also fed on treated food. The maximum mortality among treated larvae feeding on untreated

TABLE 1. Effectiveness of different insecticides for the control of the red hairy caterpillar (4th and 5th stage).

Insecticide kg ai/ha	Mean per cent mortality after 48 hours of feeding				
	Treated larvae and untreated food	Treated larvae and treated food	Untreated larvae and treated food (days after spray)		
			0	2	4
Endosulfan 0.75 (Thiodan 35 EC)	87.3 (69.15)	83.2 (65.77)	57.8 (49.48)	42.2 (40.52)	12.8 (20.98)
Carbaryl 1.25 (Sevin 50 WP)	75.6 (60.40)	60.1 (50.80)	48.9 (44.37)	35.5 (36.57)	16.9 (21.26)
Fenitrothion 1.00 (Folithion 50 EC)	80.3 (63.64)	56.8 (54.80)	55.5 (48.18)	35.5 (36.57)	17.6 (24.83)
DDT 1.25 (DDT 50 WP)	68.9 (56.13)	60.3 (50.92)	46.7 (43.11)	30.4 (33.49)	23.11 (15.4)
Monocrotophos 0.50 (Nuvacron 40 WSC)	99.2 (85.00)	97.0 (80.00)	82.3 (65.16)	44.4 (41.81)	39.9 (39.19)
Quinalphos 0.75 (Ekalux 35 EC)	91.3 (72.87)	87.2 (69.01)	71.2 (57.51)	37.7 (37.90)	32.6 (34.82)
Phosalone 0.75 (Zolone 35 EC)	71.4 (57.65)	66.7 (54.76)	53.3 (46.92)	27.7 (31.74)	13.3 (21.39)
Phenthoate 0.50 (Phendal 50 EC)	88.9 (70.74)	80.0 (63.44)	68.9 (56.14)	35.5 (36.57)	27.7 (31.74)
Control	8.7 (17.13)	4.4 (12.13)	3.0 (10.00)	3.0 (10.00)	8.7 (17.13)
CD (P=0.05)	(8.48)	(10.83)	(6.84)	(6.55)	(6.72)

Parentheses are angular transformations.

and treated food was 99.2, and 97.0 per cent, respectively. This was followed by endosulfan and phenthoate. The mortality among the untreated caterpillar feeding on treated food was comparatively less. The mortality was significantly more in treated plots and varied from 46.7—82.3, 27.7—44.4 and 12.8—39.9 per cent in 0, 2 and 4 days old spray deposits. The mortality was significantly more in monocrotophos in 0 day old spray deposits. But in 2 day old spray deposit there was no difference between monocrotophos, endosulfan, carbaryl, fenitrothion, quinalphos and phenthoate. There was no significant difference in quinalphos and monocrotophos having 4 days old deposits. It is also clear 4 days after spraying there was 50.51 to 77.85 per cent reduction in mortality as compared to 0 day old spray deposits. Monocrotophos, quinalphos and endosulfan have been found to be effective against Bihar hairy caterpillar (SIHDU & DHAWAN, 1980). PRADHAN *et al.* (1960) and TRIPATHI (1966) also reported endosulfan to be effective against red hairy caterpillar.

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EVALUATION OF DIFFERENT TRAP DESIGNS FOR TRAPPING PINK BOLLWORM MALES

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Two experiments were conducted to evaluate the efficiency of trap designs using pherocone caps impregnated with gossyplure as dispenser and Stickem as trapping medium. PAU traps made from 2 kg capacity tin boxes gave significantly more catch (250.91 moths) of pink bollworm males than the remaining three types made from indigenous material. As compared to Zoecone and Sharma traps, PAU trap was as good as Zoecone trap and was significantly far superior than Sharma trap. So PAU traps can be easily used for trapping pink bollworm male and is being more economical, effective and easy to fabricate from 2 kg capacity tin boxes.

(Key words: trap designs, evaluation of trapping, pink bollworm males, pheromone)

INTRODUCTION

Sex pheromones are used now-a-days in survey, timing of sprays and male annihilation technique for the control of pink bollworm. For any pheromone experimentation and survey work it is important to have economical and effective traps. In case the timing of sprays is done on the basis of moth catch, the present and potential population must be known, and maximum number of moths must be captured to ensure accurate data on the basis of which the spraying is done.

In the U S A numerous trap designs have been tested (SHARMA *et al.* 1973; MARKS, 1976: FORSTER *et al.*, 1977). In India, BINDRA & co-workers (1978) tested different type of trap designs. In the present investigation the objective was to determine the effect of various trap designs on catch of pink bollworm and to develop simple, inexpensive trap that will capture large numbers of attracted moths.

MATERIALS AND METHODS

In the first experiment four different types of empty in boxes (Table 1) were tested for their efficacy in trapping moths by using pherocone caps supplied by Zoecone Corporation of California U S A as dispenser and Stickem as trapping medium. The rectangular tins ($22 \times 14 \times 6.5$ and $23 \times 18 \times 6$ cm) were provided with 4 and 6 holes and circular boxes (25×4 m) with 4 holes of size 2.5×5.0 cm. The PAU trap was made from 2 kg capacity tin (13.5×16.0 cm) with 3 holes. The experiment was in Latin square with trap to trap distance 20 meters. The traps were placed at crop height. The dispenser was changed every two weeks. Number of moths caught on surface of Stickem were counted and removed daily for six weeks.

In second experiment the PAU trap which gave maximum catch in first experiment was compared with Zoecon traps (supplied by Zoecon Corporation of California, U S A), Sharma trap (SHARMA *et al.*, 1973) and modified cylindrical trap. The experiment was conducted like the first experiment except that in Sharma trap no Stickem was used. These experiments were conducted during August to October, when the crop was in flowering stage.

TABLE 1. Catches of pink bollworm males in different improvised trap designs.

Trap design		Size (cm)	Holes (2.5 × 5.0 cm)	Moths caught per trap (Total of 6 weeks)
Rectangular	1	22 × 14 × 6.5	4	176.36 (13.28)
	2	23 × 18 × 6	6	203.06 (14.25)
Circular		25 × 4	4	181.78 (13.49)
PAU		13.5 × 16.0	3	250.91 (15.84)
CD (p = 0.05)				(1.45)

Figures in parentheses are $\sqrt{n}$ transformations.

TABLE 2. Comparison of pink bollworm moth catch in PAU trap with other trap designs.

Trap design	Moths caught per trap (Total of 6 weeks)
PAU	312.58 (17.68)
Zoecone	324.00 (18.00)
Sharma	30.91 (5.56)
Modified cylindrical	20.25 (4.50)
CD (p = 0.05)	(1.67)

Figures in parentheses are $\sqrt{n}$ transformations.

RESULTS AND DISCUSSION

In the first experiment maximum number of moths caught in PAU trap (250.91 moths) than in other trap designs which do not differ significantly. In the second experiment maximum moth catch was in Zoecone (324.00) followed by PAU trap. There was no difference between two types of traps and both were better than Sharma- and modified cylindrical trap. There was also no significant difference in latter two trap designs.

From the present investigation it can be concluded that PAU trap is most effective out of the indigenous traps tested in trapping the attracted moths. It was equally effective as compared to Zoecone traps and proved much superior to Sharma traps.

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COMMENTS ON THE GENUS *KOBUZO* KONO (COLEOPTERA : CURCULIONIDAE : HYLOBIINAE) WITH THE DESCRIPTION OF A NEW SPECIES FROM INDIA

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The genus *Kobuzo* Kono is so far represented by 4 oriental species, one each from Japan, Formosa, Burma and India. Another species *K. multituberculata* sp. nov. from West Bengal is being described in this communication. The characters of the genitalia have been included in the revised characterization of the genus and a key to Indian species has been given.

(*Key words:* comments, *Kobuzo*, *K. multituberculata*, new species)

The genus *Kobuzo* Kono was erected by Kono (1933) for accommodating two species namely *Hylobius rectirostris* Roel. (type species) and *K. kikuchii* Kono. Two more species i. e., *K. crassus* Mshl. from India (Marshall, 1935) and *K. binodosus* Mshl. from Burma (Marshall, 1948) have also since been described under this genus. The authors have studied the known Indian species and a new species from West Bengal which is being described in the present communication. An elaborated characterization of the genus and a key to two Indian species is also being given.

Genus **Kobuzo** Kono

Kono, Insecta matsum., 1933, 7, pp.182-189.

Frons broad, broader than base of rostrum; eyes latero-ventral, rounded below. Rostrum straight, provided with a pair of lateral longitudinal depressions one above each scrobe, marked with two dorsal furrows. Funicle with segment 7 contiguous with club; club with segment 2 significantly smaller than 1. Pronotum bisinuate at base and rounded at apex, with broad postocular lobes, its surface granulate. Elytra with distinct humeral angles, each with a tubercle at top of posterior declivity. Mesepimeron broad, separated from mesepisternum by a deep furrow; metasternum granulate. Femora abruptly claviform apically; tibiae each with a premucro, external fringe of corbel apical and not clearly oblique to axis of body. Intercoxal process between hindcoxae broad, abdominal sternite 1 separated from 2 by a deep suture. Male genitalia with aedeagal apodemes longer than aedeagus: phallotreme oval. Female genitalia with coxites long; spiculum ventrale Y-shaped.

Type-species: *Kobuzo rectirostris* (Roel.)

Kobuzo crassus Mshl.

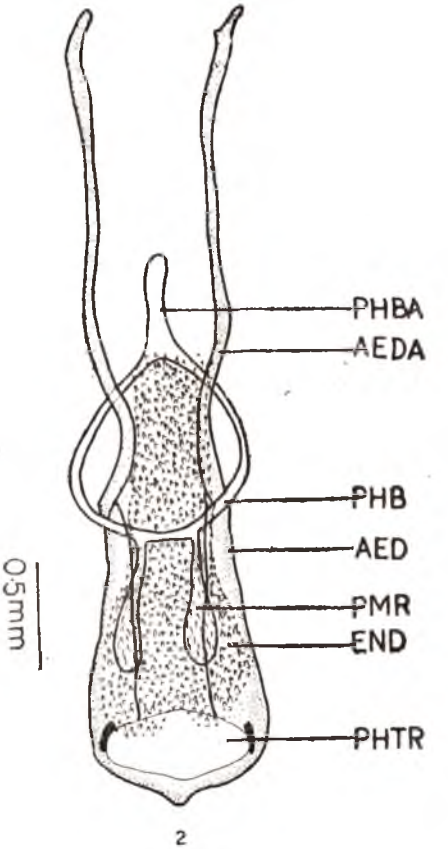
Marshall, Ind. For. Rec. N. Delhi, 1935 p. 205.

The following information on the male external genitalia is being added.

Male genitalia with aedeagus uniformly sclerotized and short, narrow at base and gradually broadened towards apex, apex produced into a small median lobe: phallotreme large, transverse subapical, with a pair of thin and long chitinized

plates one on either side; aedeagal apodemes very long, much longer than aedeagus, each slightly curved inwardly near base and weakly sclerotized at free end; endophallus beset with uniformly distributed short tubercles. Phallobase uniformly sclerotized; parameres long, weakly sclerotized, separated at base; phallobasic apodeme slightly broader than aedeagal apodemes and almost one-fifth of their lengths, with apical end of each slightly curved.

Photograph of adult *Kobuzo crassus* Mshl.



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Male genitalia of *Kobuzo crassus* Mshl.

ABBREVIATIONS

AED—Aedeagus; AEDA—Aedeagal apodeme; CX—Coxite; END—Endophallus; PHB—Phallobase; PHBA—Phallobasic apodeme; PHTR—Phallotreme; PMR—Paramere; ST—Sternite; STY—Styli; SV—Spiculum ventrale.

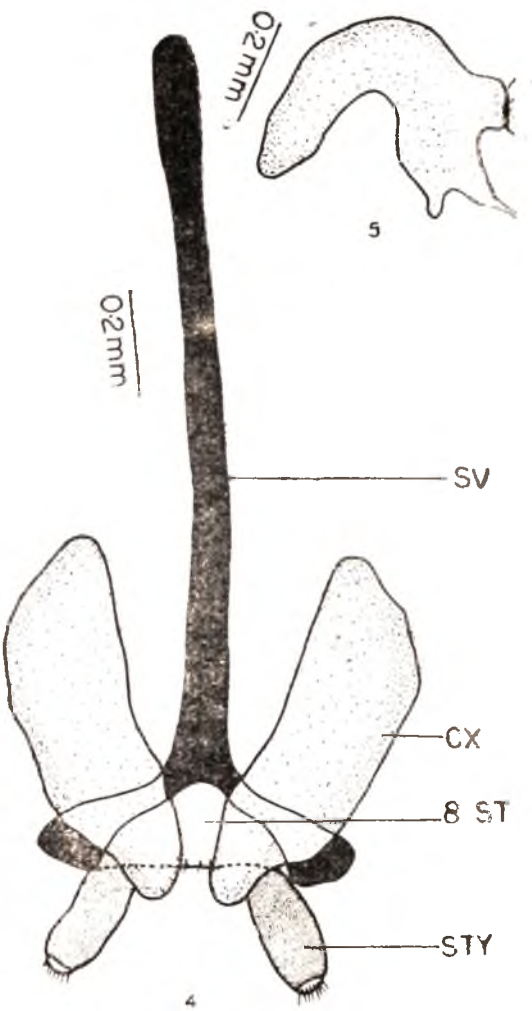
Kobuzo multituberculata sp. nov.

Head fuliginous, closely and deeply punctate, each punture beset with a golden yellow seta; frons as broad as base of rostrum, with a median sulcus in front; eyes piceous, letero-ventral, almost in level with surface of head, rostrum fuliginous, almost as long as pronotum, gradually narrowed towards middle and again broadened near apex; surface of rostrum punctate, puncutres close and coarse at apex with each puncture beset with a pale yellow seta, two lateral sulci running from base upto antennal insertions; scrobes oblique, each broader at posterior end. Antennae ferrugineous, small, inserted in apical half of rostrum; scape almost as long as funicle, clavate, finely punctate, each puncture beset with a pale yellow seta; funicle 7-segmented, segment 1 slender and longer than 2, 3 to 6 transverse, 7 broadest

of all and distinct from club; club small oval, pubescent, 3-segmented, intersegmental sutures almost striaght, with apical segment acuminate.

Pronotum fuliginous, broader than long, with sides rounded, slightly constricted near apex, its apical margin sinuate, and basal margin bisinuate; surface of pronotum tuberculate and each tubercle punctate, tubercles absent in apical one-third where surface deeply punctate and each puncture beset with an yellow seta,

Photograph of adult *Kobuzo multituberculata* sp. nov.



Female genitalia & spermatheca of *Kobuzo multituberculata* sp. nov.

an indistinct carina running in middle. Scutellum fuliginous, finely punctate, furnished with golden yellow setae. Elytra fuliginous, longer than broad, broader than base of rostrum, with distinct rectangular humeral angles, parallel-sided till middle and then narrowed towards apices, their apices jointly rounded; surface of each elytron marked with striae formed of broad punctures, apical two-third part of each with small and distinct punctures, each puncture beset with an yellow seta; intervals broader than striae, finely punctate and each puncture furnished with a small yellow seta, marked in middle with irregular black spots, irregularly tuberculate, interval 3 with a tubercle at base posterior calli forming prominent obtuse tubercles subapically. Legs fuliginous, long, stout, uniformly punctate, each puncture carrying an yellow seta; femora clavate, each toothed ventrally near apex; tibiae each with a premucro, anterior tibiae longer than posterior two pairs; tarsal

segment three strongly bilobed; claws free. Thoracic sternites ochraceous; prosternum darker in colour, coarsly punctate and each puncture beset with an yellow seta, its apical margin deeply sinuate, basal margin truncate and fringed with light yellow setae; mesosternum finely punctate, beset with dense yellow setae with setae longer and sparse on lateral sides; metasternum uniformly punctate and beset with dense yellow setae. Abdominal sternites ochraceous, uniformly and deeply punctate with each puncture carrying an yellow seta, intercoxal process between hindcoxae acuminate; sternite 2 shorter than 3 and 4 taken together.

Female genitalia with coxites long, longer than broad, almost parallel-sides, weakly sclerotized; styli longer than broad, strongly sclerotized, each with many short setae at apex. Spiculum ventrale Y-shaped, unevenly sclerotized, anterior arm directed forwards and very long, with lateral arms short and almost at right angle to each other. Spermatheca uniformly sclerotized, curved at middle; cornu long with subacuminate apex; collum slightly elongated, broad at base and gradually narrowed towards distal end; ramus globular, its apical end rounded.

MEASUREMENTS

		Breadth
Body length:	13.9—14.2mm,	12.7—12.8mm.
Head length:	0.8—0.9mm,	2.1mm.
Rostrum length:	3.1—3.2mm,	1.2—1.3mm.
Prothorax length:	2.8mm,	3.8mm.
Elytra length:	7.2—7.3mm,	5.6mm.

Holotype ♀, **Paratype** 1 ♀: INDIA, WEST BENGAL, Korseong; collected from *Quercus spicata*, Sukesha Sood. Material in Entomology Section, Department of Zoology, Panjab University, Chandigarh.

Remarks: The present species is different from *K. crassus* Mshl. and also from *K. binodosus* Mshl. as has been noticed from the study of these species in the British museum (Natural History), London. It differs from *K. crassus* Mshl. in having an oval antennal club and numerous tubercles and several black spots on the elytra. The antennal club in *K. crassus* is oblong, its elytra lack any black spots and each of them carries only two tubercles. Moreover, *K. multituberculata* sp. nov. is distinctly smaller in size than *K. crassus* Mshl., being only 13.9—14.2mm. long as compared to 17.1 mm length of *K. crassus* Mshl.

KEY TO THE INDIAN SPECIES OF GENUS *KOBUZO* KONO

Ground colour ferrugineous; Body length 17.1 mm. Antennal club oblong. Elytra unicolorus, each with 2 tubercles one on third interval and other subapical.....*crassus* Mshl.

Ground colour fuliginous; Body length 13.9—14.2 mm. Antennal club oval. Elytra with irregular black spots in middle, each with several additional tubercles.....*multituberculata* sp. nov.

Acknowledgements:—The authors are grateful to the Indian Council of Agricultural Research and United States Department of Agriculture, for financing a 5 year project on family Curculionidae under which this work has been carried out. Thanks are also due to Dr. Sen Sarma, Forest Entomologist, Forest Research Institute, Dehradun and Dr. R. T. Thompson of British Museum (Natural History), London for allowing the comparison of collection. The authors are also grateful to Chairman, Department of Zoology, Punjab University, Chandigarh for providing necessary research facilities.

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BRIEF COMMUNICATION

RELATIVE CONTACT TOXICITY OF SOME NEWER INSECTICIDES TO ADULTS OF BANANA APHID *PENTALONIA NIGRONERVOSA* COQ.

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(Received 1 May 1980)

Based on LD_{50} values ascertained in laboratory studies, malathion was found to be the most highly toxic insecticide to the banana aphid *Pentalonia nigronervosa* Coq. followed in the descending order by monocrotophos, dimethoate, quinalphos, fenvalerate, phosalone, fenitrothion and endosulfan.

(*Key words*: banana aphid, relative toxicity of insecticides)

The banana aphid *Pentalonia nigronervosa* is the vector of the bunchy top disease of banana and hence its control is important in preventing the spread of the disease. The insecticide treatments so far found effective for their control are sprays of parathion (JOHNSON, 1965), endrin and diazinon (MENON & CHRISTUDAS, 1966) and granules of disulfoton and phorate (NAIR *et al.*, 1973). As no information is available on the use of newer insecticides for the control of the aphid, laboratory assessment of the relative toxicity of such insecticides has been undertaken; results of these are presented in this note.

P. nigronervosa was reared on potted banana plants. Wingless adults were used for the experiment. Lots of insects taken in petridishes were sprayed with graded concentrations of insecticides under Potter's Tower. The concentrations of the insecticide (Table 1) were formulated from technical grades using benzene as solvent and Triton X 100 as emulsifier, keeping the concentration of these in the dilutions at 5 and 0.625% respectively. Five to six graded dilutions were made with each insecticide. After spraying, the aphids were dried under fan for 5 minutes and transferred to fresh bits of banana petioles kept in clean petridishes; the petridishes were then kept at 30° ± 10°C and mortality counts taken after 24 hours. The data were subjected to probit analysis and LD_{50} values determined.

Results presented (Table 1) showed that out of the eight insecticides tested malathion was the most highly toxic with an LD_{50} of 0.0003041. This is followed in the descending order by monocrotophos, dimethoate, quinalphos, fenvalerate, phosalone, fenitrothion and endosulfan. Compared with malathion whose toxicity is taken as 1, the relative toxicities of other insecticides were 0.78, 0.69, 0.56, 0.37, 0.12, 0.10 and 0.06 respectively. Monocrotophos and dimethoate which were systemic poisons ranked close to malathion indicating that they have high contact toxicity also.

Comparing the toxicity of the insecticide under trial to *Aphis craccivora* (excepting malathion and dimethoate, BABY, 1978) it is found that *P. nigronervosa* was more

TABLE 1. Relative toxicity of different pesticides to the adults of *Pentalonia nigronervesa*.

Insecticide	Heteregenicity	Regression equation	LC_{50}	Fidutial limit	Relative toxicity
Malathion	X^2 (3) = 2.189	Y = 3.1583X + 1.2418	0.0003041	0.0002065 – 0.0004477	1.00
Quinalphos	X^2 (3) = 2.142	Y = 4.1380X + 1.0238	0.000547	0.000234 – 0.000915	0.56
Fenitrothion	X^2 (4) = 2.313	Y = 4.4013X + 1.2692	0.002963	0.001858 – 0.004725	0.10
Phosalone *	X^2 (3) = 9.106	Y = 1.847 X + 2.4024	0.002639	0.001547 – 0.004553	0.12
Dimethoate	X^2 (3) = 1.691	Y = 4.2451X + 1.1783	0.0004365	0.0002855 – 0.006695	0.69
Monocrotophos	X^2 (3) = 1.029	Y = 4.2976X + 1.1692	0.00039	0.0002145 – 0.0007411	0.78
Endosulfan	X^2 (3) = 4.134	Y = 3.8440X + 1.7160	0.00472	0.003522 – 0.006320	0.06
Fenvalcrate	X^2 (3) = 5.33	Y = 3.6274X + 1.4909	0.00083	0.0005838 – 0.001175	0.37

* Except for phosalone, none of the other cases were found to be heterogenous at P = 0.05. Y = Probit kill. X = 10g concentration.
LC_{50} = Concentration calculated to give 50% mertality.

TABLE 2. Toxicity of insecticides to *P. nigronervosa* as compared to *A. craccivora*.

Insecticides.	LD_{50} values of		LD_{50} of *P. nigronervosa* / LD_{50} of *A. craccivora*
	A. craccivora	*P. nigronervosa*	
Endosulfan	0.001986	0.00472	2.377
Quinalphos	0.003376	0.000547	0.167
Fenitrothion	0.003783	0.00963	0.783
Phosalone	0.0003908	0.002649	6.778
Monocrotophos	0.0004223	0.00039	0.924

susceptible to quinalphos, fenitrothion and monocrotophos than *A. craccivora* while it was more resistant to phosalone and endosulfan than *A. craccivora* (Table 2).

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BRIEF COMMUNICATION

FURTHER STUDIES ON INFLUENCE OF GRANULOSIS INFECTION ON THE LARVAE OF *PERICALLIA RICINI* FAB. (ARCTIIDAE : LEPIDOPTERA)

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(Received 16 May 1980)

Granulosis virus infection resulted in a reduction of length and weight of the larvae of *Pericallia ricini*. This indicates a retardation in larval growth due to the disease infection.
(Key words: granulosis of *Pericallia ricini*, larval weight, length)

JACOB *et al.* (1972) recorded the incidence of a granulosis in the larvae of *Pericallia ricini* from Vellayani and PHILIP & JACOB (1980) reported the effect of the granulosis in food consumption, growth rate and utilisation of food by larvae of *Pericallia ricini*. The present paper describes the effect of this virus infection on the weight and length of the larvae.

Third instar larvae were inoculated with 5 microlitres each of a concentrated virus suspension by the spot feeding technique deviced by JACOB (1972) and larvae fed on leaf spots treated with 0.1 per cent teepol served as control. Both the inoculated and control larvae were released individually in hurricane chimneys and provided with fresh uncontaminated castor leaves. Twenty larvae each of the control and inoculated groups which had eaten up the treated spots completely within 4 hours were used for estimation of body weight and larval measurements. The estimations of weight and length were made immediately after feeding the leaf spot and at succeeding intervals of 24 h. The larvae to be measured was slightly pressed to the scale and the reading taken. The data was analysed by 't' test.

The results presented in Table 1 show that the healthy larvae registered an increase in wet weight as they advanced in age. But diseased larvae showed a slow gain in weight until 6 days after treatment and thereafter they did not show any further increase in weight. Thus at the end of 11 days after inoculation the diseased larvae had a mean weight of only 0.101 ± 0.005 g while the healthy larvae had a mean weight of 1.516 ±0.051 g which was about 15 times that of diseased ones. The diseased larvae had significantly lower weights than the healthy ones at all intervals from third day onwards.

As regards effect of the infection on larveal length (Table 2) it will be observed that the diseased larvae showed a gradual increase in length upto 7 days after treatment but at a rate lesser than that in the healthy ones. After 11 days of inoculation the diseased larvae had a mean length of only 2.50 ± 0.023 cm while the healthy larvae had a mean length of 5.38 ± 0.037 cm which was nearly two

TABLE 1. Mean fresh weight of healthy and granulosis infected larvae of *P. ricini* on different days following treatment.

Post-inoculation period in days.	Mean fresh weight ±SE (g) healthy.	Granulosis treated.
1	0.029 ± 0.001	0.030 ± 0.0002
2	0.060 ± 0.002	0.050 ± 0.0003
3	0.126 ± 0.006	0.032 ± 0.0025
4	0.184 ± 0.015	0.087 ± 0.005
5	0.317 ± 0.022	0.099 ± 0.005
6	0.427 ± 0.020	0.105 ± 0.004
7	0.506 ± 0.025	0.102 ± 0.004
8	0.661 ± 0.070	0.102 ± 0 050
9	1.107 ± 0.088	0.107 ± 0.011
10	1.376 ± 0.066	0.101 ± 0.005
11	1.516 ± 0.051	0.101 ± 0.005
Mean	0.574	0.094

TABLE 2. Mean length of healthy and granulosis-infected larvae of *P. ricini*.

Post-inoculation period in days.	Mean length of larva in cm ± SE	
	Healthy	Granulosis infected
1	1.13 ± 0.034	1.05 ± 0.022
2	1.55 ± 0.032	1.31 ± 0.018
3	2.06 ± 0.016	1.61 ± 0.023
4	2.55 ± 0.017	1.86 ± 0.018
5	3.17 ± 0.021	2.04 ± 0 020
6	3.58 ± 0.025	.18 ± 0.0202
7	3.96 ± 0.022	2.28 ± 0.020
8	4.37 ± 0.037	2.28 ± 0.020
9	4.77 ± 0.037	2.29 ± 0.020
10	5.10 ± 0.037	2.40 ± 0.020
11	5.38 ± 0.037	2.50 ± 0.023
Mean	3.42	1.98

times that of diseased ones. Further the mean length of diseased larvae was significantly lesser than that of corresponding healthy ones at all intervals from third day onwards.

The results thus show that the virus infection had a negative influence on the weight and length of larvae, indicating a retardation in growth. Similar observations were made in the case of nuclear polyhedrosis infected larvae of *Ceramica picta* by ADAMS *et al.* (1968) and in *Spodoptera litura* by JACOB & SUBRAMANIAM (1974).

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BRIEF COMMUNICATION

EFFECT OF NPV OF THE ARMYWORM *MYTHIMNA (PSEUDALETIA) SEPARATA* ON ERI SILKWORM *PHILOSAMIA RICINI* (HUTT.)

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Eri silkworm *Philosamia ricini* larvae were administered witht NPV of the armyworm *Mythimna (Pseudaletia) separata*, a serious agricultural pest, by three different routes viz. topical, intrahaemocoelic and oral. The larvae were treated with following concentrations: 10×10^5 PIBs/L., 10×10^6 PIBs/L, 10×10^7 PIBs/L and 10×10^8 PIBs/L. The larvae subjected to three experiments showed neither any signs and symptoms nor mortality due to polyhedrosis. Thus it appears that the NPV of *M. (P.) separata* is safe to eri silkworm *Ph. ricini*.

(*Key words:* NPV effect on eri silkworm, armyworm NPV, *Mythimna separata*)

Nuclear polyhedrosis virus (NPV) of the armyworm *Mythimna (Pseudaletia) separata* is successfully used to control its host which is a serious agricultural pest (NEELGUND, 1975). However, large scale use of NPV needs safety tests on beneficial insects like silkworms. The present paper reports the effect NPV of the armyworm *M. (R.) separata* on eri silkworm *Ph. ricini*.

Eri silkworm larvae reared on castor leaves were treated following viral concentrations higher than those required to infect the armyworm: 10×10^5 polyhedral inclusion bodies/ larvae, 10×10^6 PIBs/L, 10×10^7 PIBs/L and 10×10^8 PIBs/L. The pathogen was applied through oral, topical and intrahemocoelic routes (Expt. I, II and III respectively). In oral and topical applications 50 third instar larvae were used in five replications while in the intrahemocoelic injections 40 fifth instar larvae were used in four replications. In the controls sterile distilled water alone was used instead of virus inoculum. In the experiment III another set of control larvae was treated with the alkaline solution used to free the viral rods from the PIBs. Alkaline solution used in the 3rd experiment contained 0.004 M Na_2CO_3 and 0.05 M NaCl mixed with water. Observations were made daily on the larval mortality due to NPV and other causes, the larval and pupal duration.

Results obtained from the three experiments could be summarized as follows. The treated larvae showed neither any signs and symptoms nor mortality due to polyhedrosis. Survival rate of pupae and adult emergence was 92—100%. Further, the treated larvae did not significantly differ from the controls in their intermolt and larval duration in experiments I and II. In experiment III treated larvae did not differ from controls in cocoon formation. Hence it appears that NPV of the armyworm is non-infective to eri silkworm *Ph. ricini*. In oral treatment (experiment I) the fate of the PIBs in the bodies of eri silkworm by periodical examination of the gut and faecal matter was investigated.

Though PIBs could be found in the gut lumen but not in the faecal matter of the treated larvae after 6h from the time of treatment, they were not detected in the gut or in faecal matter after 24h. These findings suggest that though the protein coat of PIBs is dissolved in the gut, the virus is non-infective to eri silkworm *Ph. ricini*. In topical application (experiment II) the exuviae were checked for the presence of PIBs and they could be found on the surface of exuviae left by the treated larvae during molting, suggesting that the polyhedral bodies have not penetrated the body wall of eri silkworm.

Totally 187 cross-transmission of NPV among the insect species were attempted and 60 were successful indicating that the viruses are generally species specific (IGNOFFO, 1968). ARUGA *et al.* (1960) when fed with the NPV of the *Barathra brassicae* and *Hyphentria cunea* failed to get any infectivity to *Bombyx mori*. SMITH & XEROS (1952) could not succeed in cross-tranmitting the NPV of *Malcosoma alpica, M. distria, M. americanum* and *M. plaviale* to *B. mori*. DON CANERDAY (1968) investigating the effect of high dosage level of cabbage looper NPV on some related Plusinae viz., *Pseudaplusia includens, Rachiplusia ou* and *Angraplua biloba* found that it was innocuous to these species when fed orally. Similarly the present findings suggest that the NPV of the armyworm *M. (P.) separata* is safe to eri silkworm *Ph. ricini*. Recently this pathogen has also been demonstrated to be innocuous to *B. mori* (DHADUTI & MATHAD, 1979) and *Antheraea mylitta* (DHADUTI & MATHAD, 1979).

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BRIEF COMMUNICATION

SOME OBSERVATIONS ON FIELD POPULATION OF *EMPOASCA FLAVASCENS* FABRICIUS, A JASSID PEST ON CASTORBEANS CROP IN JODHPUR (RAJASTHAN)

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(Received 16 September 1980)

Four castorbeans cultivars namely, *Aruna, Assam local, Bilara local* and *Udaipur local* were sown in the last week of March, 1979. The jassid population per plant on these four castorbeans cultivars in the local agroclimatic conditions shows that the maximum and minimum activity of the pest was recorded from April to the first week of May and the first week of May to the last week of June respectively. The *Udaipur local* has shown infestation throughout the investigation period.

(Key words: Empoasca flavascens, pest of castorbeans)

Castorbeans *(Ricinus communis* L.*)* is an important commercial crop in India. Castorbeans is grown in Rajasthan both as a sole crop and in association with several legumes (pigeon pea, groundnut etc.) and cash crops (chillies, cotton, fennel etc.). One of its important pests is castor jassid (*Empoasca flavascens* F.*)* which sucks up the sap from the leaves and tender shoots and these common leaf hoppers cause great malady known as 'hopperburn' to castorbeans. Castorbeans leaves are used to feed the eri silkworms (*Philosamia ricini* H.) reared at field station, Department of Zoology throughout the year. Therefore, an experiment was conducted to observe the field population of this pest in summer season when the leaves are in great demand for eri silkworm rearing.

These four castorbeans cultivars were sown at the end of March, 1979 and observations on these cultivars were started from the first week of April, 1979. The experiments were replicated three times with equal plot size 4.5 m × 6 m having inter-rows and intra-row plant distance of 90 cm and 30 cm respectively. In each plot 6 plants were randomly selected and tagged in order to record all the observations on them only. The record of jassid population was started from the first week of April, which continued up to the last week of June. Only nymphs were taken into consideration for recording the pest population at weekly interval. All the weekly counts of the total jassid population per plant along with weekly average of maximum and minimum temperature, mean relative humidity and total weekly rainfall have been presented in Figs. 1 and 2.

The data summarized in Figs. 1 & 2 show that the jassid population on all the four castorbeans cultivars was maximum on 10 April, 1979 when average maximum and minimum temperature from 32.1 to 40.7°C and 16.1 to 26.3°C and mean relative humidity from 11.5 to 35.5 per cent. With a slight decrease in atmospheric temperature and increase in the

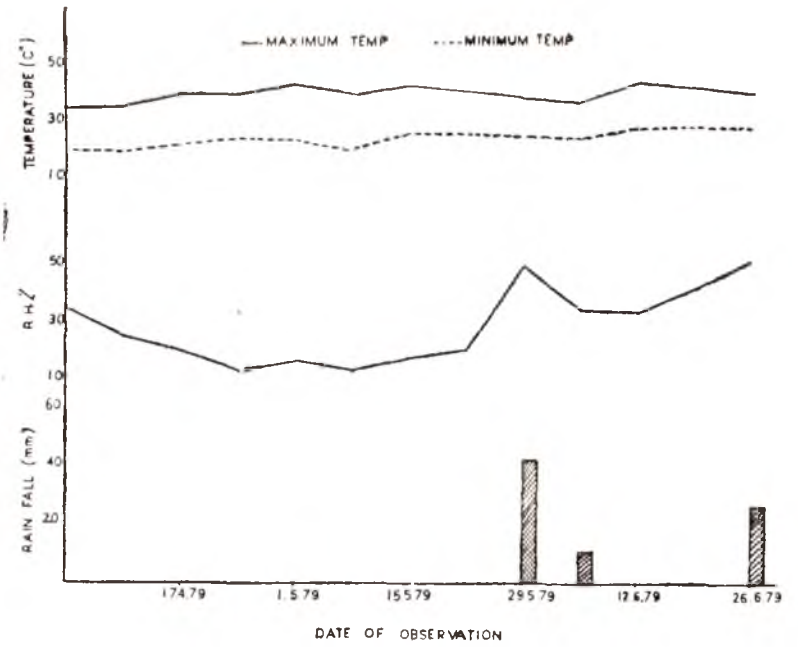

Fig. 1. Weekly rainfall, relative humidity and temperature Jodhpur during period of investigation.

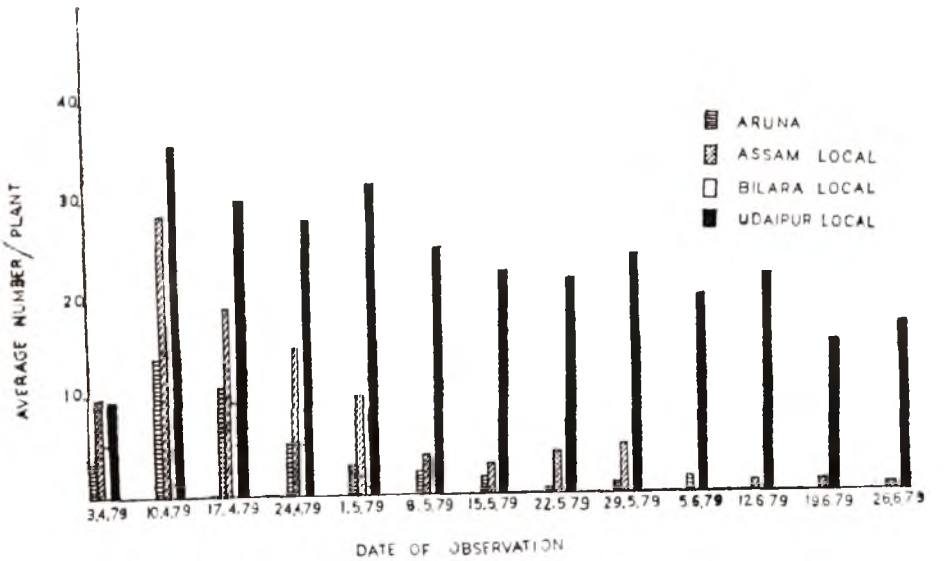

Fig. 2. Population of jassids on four castor cultivars.

relative humidity due to onset of monsoon rains after the last week of May and the first week of June, the jassid population showing a slight increase and the minimum activity of the pest was recorded from the first week of May to the last week of June

except castor *Udaipur local*. The pest population declined to zero on castor *Bilara local* and *Aruna* from 1 to 29 May 1979 respectively. The jassid population survived on castor *Udaipur* and *Assam local* from April to June. Castor *Bilara local* and *Aruna* are bloomy caltivars which attract minimum number of jassids while the other two cultivars, namely castor *Udaipur* and *Assam local* are glabrous and are highly susceptible to the jassid attack.

Based on the present results the castor beans cultivars are arranged in decreasing order of their resistance to jassid: Castor *Bilara local* > *Aruna* > Castor *Assam local* > Castor *Udaipur local*. The present results are in accordance with the findings of ATWAL *et al.* (1969) who recorded almost similar build up of population in case of common cotton jassid (*Empoasca devastans* I.) during the end of summer and the beginning of rainy season at Ludhiana. SAINI & CHHABRA (1968) reported the jassid population on eight castor-beans varieties and found similar relation of jassid population with meteorological factors. This indicates that most of the castor jassids occurring during summer and at the beginning of rainy season, prefer moderate temperature, high humidity and occasional rainfall as shown in Fig. 1.

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BRIEF COMMUNICATION

HOST RANGE OF TWO ENTOMOGENOUS FUNGI *SYNCEPHALASTRUM RACEMOSUM* COHN EX SCHROETER AND *PENICILLIUM OXALICUM* CURRIE AND THOM AND SAFETY TO CERTAIN CROP PLANTS

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Infectivity of the entomogenous fungi *Syncephalastrum racemosum* and *Penicillium oxalicum* to certain rice pests were studied. Both the fungi infected *Nilaparvatha lugens* while *Penicillium oxalicum* could also infect the nymphal stages of *Leptocorisa acuta*. None of the other insects tested were infected by these fungi. These entomogenous fungi were found to be safe to seven crop plants viz., bittergourd, snakegourd, amaranthus, bhindi, brinjal, cowpea and rice.

(Key words: Syncephalastrum racemosum, Penicillium oxalicum, host range, plant pathogenicity)

Syncephalasturm racemosum was noticed as a virulent pathogen of rice leaf hopper *Cicadella spectra* (DIST.) at the College of Agriculture, Vellayani by MATHAI *et al.* (1979). *Penicillium oxalicum* was reported to infect the rice leaf hopper *Cicadella spectra* (KURUVILLA *et al.*, 1979). The present paper reports the results of investigations made on the pathogenicity of these entomogenous fungi to other rice pests and to seven common crop plants viz., bittergourd, snakegourd, amaranthus, bhindi, brinjal, cowpea and rice.

The fungal cultures obtained from diseased hoppers were maintained in Czapek's agar medium. The catepillars tested were inoculated by allowing them to crawl for one hour over heavily sporulated 4 day old cultures and reared on rice seedlings enclosed in hurricane lantern chimneys. The bugs and beetles under test were released on rice plants caged in chimneys and sprayed with a concentrated suspension of the spores collected from 4 day old cultures. Mortality of the insects was observed daily till all were dead or pupated as the case may be. Pathogenicity was confirmed by reisolating the same fungus from the dead specimens. Pathogenicity of the fungi to the crop plants was assessed by the following methods: (1) Seed treatment in which twenty seeds each of bittergourd, snakegourd, bhindi and cowpea and 5 grams each of brinjal, amaranthus and rice were soaked in 10 ml of spore suspension for overnight. Then the seeds were sown in flower pots at the rate of 3 seeds per pot. Seeds soaked in sterile water served as control. (2) Leaf treatments in which one month old plants were used. Injury was made on leaves by pin pricks and culture bits were placed over the injured spots and covered with moist cotton. Injured spots covered with moist cotton alone served as control. (3) Soil treatment in which surface soils of 10 cm diameter flower pots were mixed with 30 ml

TABLE 1. Infectivity of *S. racemosum* and *P. oxalicum* to some insect pests of rice.

Test insect	Stage of the insects tested.	per cent mortality of insects* treated with:		Infectivity
		S. racemosum	*P. oxalicum*	
Spodoptera mauritia	Larvae	Nil	Nil	– ve
Cnaphalocrocis medinalis	Larvae	Nil	Nil	– ve
Nilaparvatha lugens	Nymphs and adults	70	72	+ ve
Menida histrio	Adults	Nil	Nil	– ve
Leptocorisa acuta	Nymphs	Nil	45	+ ve
	Adults	Nil	Nil	– ve
Altica cyanea	Adults	Nil	Nil	– ve

* There was no mortality in control and for each treatment 20 insects were used and replicated 3 times.

of the spore suspension and 2 seedlings planted in each pot. Soil mixed with 30 ml sterile water alone served as control. (4) Root treatment in which root tips of one month old seedlings of brinjal, amaranthus and rice were cut and kept immersed in the spore suspension for 3 hours and planted in flower pots at the rate of 3 seedlings per pot. In the case of bittergourd, snakegourd, bhindi and cowpea, injuries were made on the root and culture bits were placed on the injured spots and covered with moist cotton. All the above experiments were replicated three times for each crop. Observations were made daily on the condition of the plants till harvest.

The data presented in Table 1 show that both the fungi infected *Nilaparvatha lugens*. But *P. oxalicum* could also infect the nymphs of *Leptocorisa acuta* causing 45 per cent mortality and it was not infective to adults. None of the other insects were found infected by any of the two fungi. The results on the pathogenicity of *S. racemosum* and *P. oxalicum* to crop plants showed that it was not infective to any of the crop plants tested. The present finding adds to the value of these fungi as pest control agents in paddy fields as they are safe to rice plants and the common vegetables that are grown as summer crops in paddy fields.

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BRIEF COMMUNICATION

ON A NEW SPECIES OF ROOT - INFESTING APHID OF GENUS *PROTRAMA* BAKER FROM KASHMIR (HOMOPTERA : APHIDIDAE)

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Protrama salviae sp. nov, Homoptera, Aphididae), infesting the roots of *Salvia moorcroftiana* is described from Kashmir, India.

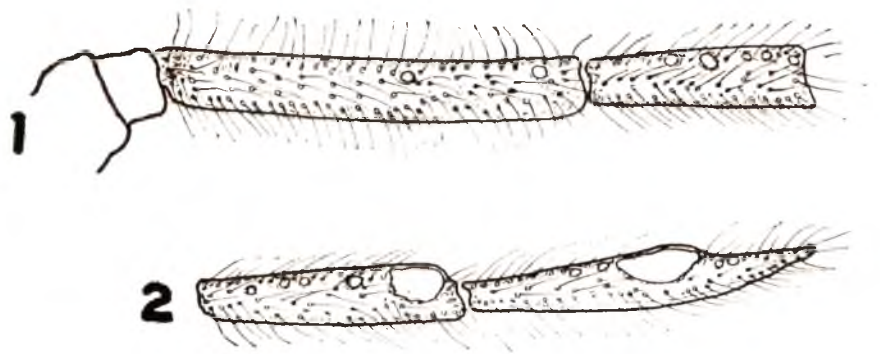
(*Key words*: new root infesting aphid, *Protrama*)

During the course of survey of aphid fauna and their parasitoids from Karhmir by BHAGAT (1980 a, b), a new species of root - infesting aphid was encountered. The description of morphological features of apterous viviparous female is given here. Both holotype and paratypes will be deposited in the Entomological Collection of Centre of Research for Development, University of Kashmir.

Protrama salviae sp. nov. (Figs. 1 & 2)

Body oval in shape, 2.8 — 3 mm in length, maximum width at middle of abdomen 1.9 mm. Head, body, antennae and appendages covered with dense fine hairs. Antenna (Figs. 1 & 2) long and 6 segmented; processus terminalis 1/4—1/5 of the base of antennal segment VI; secondary rhinaria arranged in a single row on the antennae, having 1 — 2 rhinaria on antennal segment III, 3—5 on antennal segment IV , 5—6 on segment V (primary large) and antennal segment VI (with one large oval primary and a few small accessory rhinaria). Head with a longitudinal median suture on vertex. Rostrum extending beyond the hind coxae, 1.3 — 1.4 mm long; ultimate rostral segment 1/4 times as long as second segment of hind tarsus. Siphunculi present in the form of small pigmented hairy cones. Hind tibia 1—1.2 mm in length, 1.5—1.8 times as long as antennal segment III and 2.8—3.2 times as long as antennal segment IV; tibial hairs are of single type. The second segment of hind tarsi is extremely elongated and is nearly equal to hind tibia. Legs brownish excepting uppermost parts of tibiae, which are yellowish brown in colour. The dorsum of the abdomen with pigmentation and covered with acute hairs. Tergite eight with complete band of pigmented sclerite. Fragmentary seclerites around siphunculi are also present. Cauda and sub-anal plate rounded.

Measurements of the holotype in mm: Length



Figs. 1 & 2. *Protrama salviae*, sp. nov. 1. antennal segment I—IV; 2. antennal segment V & VI.

of body 2.9; width, 1.7; antenna 1.8; antennal segments III : IV : V:VI :: 0.70 : 0.31: 0.40:0.42 + 0.05; ultimate rostral segment 0.26; second segment of hind trasus 1.1.

Holotype : Apterous viviparous female from *Salvia moorcroftiana* (Labiatae), Harvan near Dachigam, Kashmir (India), 21. x. 1975, Coll. R. C. Bhagat. **Paratypes**: 8 apterae viviparae with collectlon data same as for holotype.

Biological notes: The dirty cream coloured aphids were collected from the roots of the plants, occurring in colony and attended by the ants.

Remarks: This new species differs from the existing species of *Protrama* of the world. By the presence of tergal pigmented bands on the anterior segments of the abdomen, siphuncular cones not much smaller and smaller body size *Protrama salviae* n. sp. can be easily distinguished from another root-aphid, *Protrama penecaeca* Stroyan (Stroyan, 1964), from Jammu & Kashmir State. In *penecaeca* no trace of tergal banding on the anterior abdomen segments exist, siphuncular cones are much smaller and the body size is big. Hitherto no species of *Protrama* has been recorded from Labiatae.

Acknowledgements: Authors are indebted to Dr. H. L. G. Stroyan, Plant Pathology Laboratory, Hatching Green. Harpenden, Herts, England, for confirming the new species and for expert comments.

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REPORTS AND NEW RECORDS

A NEW REPORT OF *PENTALITOMASTIX NACOLEIAE* EADY (HYMENOPTERA, ENCYRTIDAE) AS A POLYEMBRYONIC PARASITE OF *PAROTIS VERTUMNALIS* GUEN. (LEPIDOPTERA, PYRAUSTIDAE) IN KERALA, INDIA

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Pentalitomastix nacoleiae Eady (Hymenoptera, Encyrtidae) was first reported by Eady (1960, 1961) under the name *Pseudolitomastix nacoleiae* as a parasite of the banana scab moth, *Nacoleia octasema* (Meyr.) (Lepidoptera, Pyraustidae). No published information is available on its host range and distribution, although it has been collected from Afghanistan, Assam in India and Fiji (Subba Rao, pers. comm.). Recently, this insect was found as a parasite of *Parotis vertumnalis* Guen. (Lepidoptera, Pyraustidae) in Kerala. The host insect, *P. vertumnalis* is a leaf webber of the tree, *Alstonia scholaris* (Linn.) R. Br. (Apocynaceae),

In March — June and November—December 1979, observations were made on *P. vertumnalis* caterpillars collected from Peechi, Vazhachal, Kottappara, and Thiruvalla in Kerala. Parasitism by *P. nacoleiae* was noted in samples collected from the first two places.

P. nacoleiae is a polyembryonic parasite. The adults are minute in size, measuring about 0.7mm and are light black in colour. Attacked caterpillars become sluggish, cease to feed and show a light purple tinge instead of the usual green colour. The host generally dies before pupation. The colour now fades and the integument becomes more or less translucent, through which closely packed parasites become visible. At this time the caterpillar has a mummified appearance. Parasite emergence was observed approximately 14 days after the death of the caterpillar under observation. As many as 1,200 parasites were recorded from a single host caterpillar

Acknowledgements:—Thanks are due to Dr. B. R. Subba Rao, Commonwealth Institute of Entomology for identification of the parasite and for information on its distribution. I am grateful to Dr. K. S. S. Nair, Entomologist, Kerala Forest Research Institute for encouragement and suggestions.

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A NEW HOST RECORD FOR THE SHOT-HOLE BORER OF TEA

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Among all the pests occurring in tea plantations of South India, the Scolytid beetle, *Xyleborus fornicatus* Eichh., commonly known as the 'shot-hole borer' is the most destructive, causing not only damage to the stem, but also considerable capital loss due to the ultimate death of tea bushes in severe cases of infestation. Besides tea, other economically important plants like teak, citrus, cocoa, rubber and cinchona are also attacked by this beetle.

In the tea plantation areas of Anamallais, Central Travancore, Wynaad and South Kerala, severe infestation by the shot-hole borer has been reported (Rao, 1973). During our recent visit to the estates in the Nilgiris, some trees of *Acacia decurrens* Willd. adjoining the tea plantations were found to be attacked by two species of scolytid beetles viz , *X. fornicatus* Eichh. and *X. semiopacus* Eichh. The latter species can be easily distinguished from the tea stem borer by their yellowish brown colour and large size. Moreover, 'frass' formation of the two species also differ remarkably; in *X, fornicatus* frass is powdery while in *X. semiopacus* it is of a thread like appearance.

X. fornicatus, a highly polyphagous species, originally recorded from castor plant (*Ricinis communis*) (Speyer, 1910), has since been reported to occur on 99 host plant species belonging to 36 families (Danthanarayana, 1968). Among them Leguminosae, Verbenaceae and Moraceae have the maximum number of host plants. In the family Leguminosae alone 30 species are reported as host plants of shot-hole borer, of which the major genera are *Albizzia Crotolaria*, *Bauhinia*, *Tephrosia*, *Cassia*, *Erythrina*, and *Mimosa*, and the present finding forms the first record of *Acacia decurrens* as a host plant for *X. fornicatus*.

Thanks are due to Dr. C. S. Venkata Ram, Director, UPASI Tea Research Institute, Cinchona, for his constant encouragement. The help rendered by the Commonwealth Institute of Biological Control, London, for confirming the identity of the beetle is gratefully acknowledged.

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A NEW RECORD OF *ANERISTUS CEROPLASTAE* HOWARD ON BROWN SOFT SCALE *COCCUS HESPERIDUM* L. ON A NEW HOST *(PAPAYA)* FROM INDIA

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(Received 28 June 1980)

The brown soft scale, *Coccus hesperidum* L. has a very wide distribution throughout the tropical and subtropical regions on hosts like palms, oleander, figs and different ornamentals but occur commonly on citrus (Anonymous, 1968). Nair (1975) and Nirula (1955) mentioned various hosts like citrus, coconut, areca palm and tea, being damaged by brown soft scale in India. This scale was however, recorded on papaya (*Carica papaya* L.) as occasional pest in Hawaii (Anonymous, 1974). In the present studies, the brown soft scale has been recorded for the first time on papaya in India and forms a new host record in this country.

During the month of March, 1980, papaya fruits had a very heavy infestation of brown soft scale (*C. hesperidum* On an average 34 scales were observed per square inch with a population range between 15 and 61 scales per square inch, distributed all over the fairly large sized fruits. These scales were more concentrated on the lower regions of the fruits. The affected portions of the fruit turn yellowish and thus reduce the market value of the fruits.

The brown soft scales were found parasitized by *Aneristus ceroplastae* Howward (Hym : Aphelinidae) during the monhts of March—April, 1980 to the tune of 51.8 per cent. The parasites were developing in singles mostly in each coccid (Fig. 1) and doubles in rare cases. The parasite was reported on *C. hesperidum* in USA (Anonymous, 1953). In India, the parasite, *A. ceroplastae* though recorded on other coccids, *Saisseria nigra* Nietn., *S. hemispherium* Targ., and *Ceroplastes pseudoceriferus* has not so far been recorded on *C. hesperidum* and this forms the first record from India. In view of its effective role in control of *C. hesperidum* further aspects with regard to the feasibility of utilising the parasite in biological control are worth studying.

The parasite was identified by B. R. Subba Rao and the coccid was identified by D. J. Williams, British Museum, London, to whom the authors are

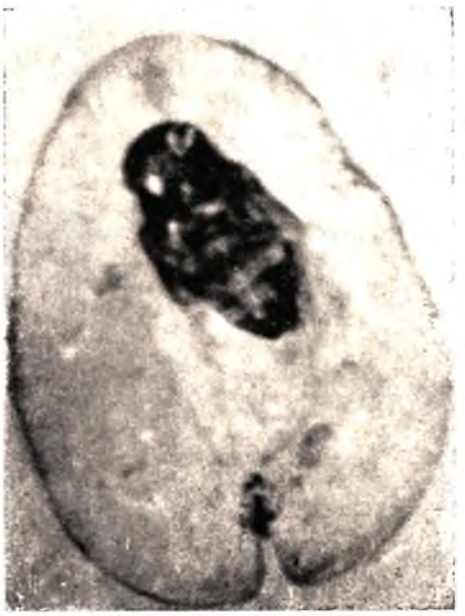

Fig. 1 The Aphelinid parasite, *Aneristus ceroplastae* Howard developing inside the brown soft scale (*Coccus hesperidum* L.)

highly thankful. Thanks are also due to Dr. K. K. Nirula, Entomologist (Plant Quarantine), ICRISAT, Hyderabad, for kindly arranging the microphotograph of the parasitised coccid.

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HYDROGEN ION CONCENTRATION IN THE DIGESTIVE TRACT OF THREE SPECIES OF INDIAN TERMITES (INSECTA : IOSPTERA)

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The pH in the alimentary canal (both in gut tissue and in gut contents) of the termites, *Neotermes bosei*, *Odontotermes distans* and *Speculitermes cyclops* have been investigated. The pH of the digestiva tract seems to be related to the type of food eaten and secretion of the corresponding enzymes. In lower termites (*N. bosei*) the gut is acidic as its food is rich in carbohydrates, whereas in higher termites (*O. distans* and *S. cyclops*) the gut is alkaline due to food being rich in protein. However, the mode of decomposition and the accumulation of the end product is also related to the pH of the gut contents

INTRODUCTION

The knowledge of hydrogen ion concentration (pH) of the digestive tract of termites is important for clear understanding of their digestive physiology. The pH of the gut contents of the termites has been studied by some authors namely, RANDALL & DOODY (1934) in *Zootermopsis angusticollis* (HAGEN), GRASSE & NOIROT (1945) in *Reticulitermes lucifugus* (ROSSI), KOVOOR (1967) in *Microcerotermes edentatus* (WAS.), NOIROT (as cited in NOIROT & NOIROT-TIMOTHEE, 1969) in *Kalotermes flavicollis* (FAB.) and SINGH (1975) in *Odontotermes obesus* (RAMB.) These authors, however, did not study the pH of the gut tissues. Further, in these investigations pH colour indicator technique was used which is subject to certain errors (WATERHOUSE, 1949). In the present study, pH of both the gut content and the gut tissues was determined with the help of a pH meter (to get more accurate results) in case of pseudoworkers/workers of *Neotermes bosei* SNYDER, *Odontotermes distans* (HOLMGREN) and *Speculitermes cyclops* (WASM.) having different food regimes.

MATERIAL AND METHODS

The test termites were obtained either from the laboratory culture (*N. bosei*) maintained at a temperature of 28°C ± 1°C and relative humidity of 95% ± 4% or from the field. Pseudoworkers/workers were dissected in double distilled water and the alimentary canal was thoroughly washed after removing the adhering tissues. After this, the fore-, the mid- and the hind-gut were severed off from each other. Each part was slit opened with the help of a fine needle and contents of each part were collected in a separate glass vial. The gut tissues were collected separately after washing them in double distilled water and the homogenate was made. The pH was determined by means of a pH meter using micro-electrode assembly (ELICO-India).

RESULTS

The results are presented in Table 1.

(a) Neotermes bosei: The pH of the gut

TABLE 1. pH of the alimentary canal of the termites (Mean and range of 5 replications).

Salivary glands/Part of the digestion tract.		*Neotermes bosei*		*Odontotermes distans*		*Speculitermes cyclops*	
		Range	Mean	Range	Mean	Range	Mean
Salivary glands		7.0–7.3	7.1	6.8–7.2	7.0	7.3–7.5	7.4
Foregut	Tissue	6.3–7.2	6.9	6.5–7.1	7.0	7.1–7.3	7.2
	Contents	5.2–6.0	5.7	6.5–6.9	6.8	6.8–7.0	6.9
Midgut	Tissue	7.2–7.5	7.2	6.5–7.5	7.1	7.7–7.9	7.8
	Contents	6.0–6.3	6.2	6.2–7.0	6.5	7.6–8.0	7.8
Hindgut (Paunch)	Tissue	6.0–6.5	6.2	7.2–7.6	7.4	7.8–8.1	7.9
	Contents	4.8–5.5	5.1	6.6–7.0	6.8	7.3–7.5	7.4
Hindgut (Colon & Rectum)	Tissue	5.8–6.7	6.6	7.1–7.3	7.2	7.5–7.7	7.6
	Contents	4.5–5.4	5.1	6.8–7.3	7.0	7.0–7.3	7.1

contents is acidic throughout the digestive tract. The contents of the foregut (pH 5.7) and the hindgut (pH 5.1) are more acidic than those of the midgut (pH 6.2). In contrast to the pH of the gut contents, a higher pH was observed in the gut tissues which are slightly alkaline in the midgut (pH 7.2), neutral in the foregut (pH 6.9) and acidic in the hindgut (pH 6.2 in paunch, 6.6 in colon and rectum).

(b) Odontotermes distans: The pH of the gut contents ranges from slightly acidic to neutral (pH 6.5 to 7.0), while the pH of the gut tissues varies from being neutral to slightly alkaline (pH 7.0 to 7.4). The pH of the gut contents is lower in the midgut (pH 6.5) than in the foregut (pH 6.8) and the hindgut (pH 6.8 in paunch; 7.0 in colon and rectum).

(c) Speculitermes cyclops: The contents of the digestive tract have an alkaline pH which manifests only slight variation. Further, the differences between the pH of the gut contents (pH ranging from 6.9 to 7.8) and the gut tissues (pH varying from 7.2 to 7.9) are also marginal. The pH of the midgut (pH 7.8) is higher than that of the foregut (pH 6.9) and the hindgut (pH 7.4 in paunch, 7.1 in colon and rectum).

The salivary glands in all the three species of termites studied are, neutral to alkaline (pH 7.0 to 7.4).

DISCUSSION AND CONCLUSION

The present observation that the contents of the alimentary canal in lower termite (*N. bosei*) is acidic throughout the digestive tract confirms the findings of RANDALL & DOODY (1934) in *Zootermopsis angusticollis* (HAGEN). In case of higher termites (*O. distans* and *S. cyclops*), the pH ranges from neutral to alkaline have also been reported in *O. obesus* (RAMB.) by SINGH (1975) and in *Coptotermes lacteus* FORG.) by EUTICK *et al.* (1976). However, exceptions to this have heen recorded by KOVOOR(1967) in *Microcerotermes edentatus* (WASM.) (gut contents alkaline to aeidic in the hindgut) and by EUTICK *et al.* (1976)

in *Nasutitermes exitiosus* (HILL) (gut contents slightly alkaline to acidic in the hindgut).

According to the pH of the gut-contents, the digestive tract can be divided into two parts. The first part comprises of those portions where the pH exhibits an increasing trend up to the midgut (as in the case of *N. bosei* and *S. cyclops*) and the second part is the one in which pH gradually decreases in the paunch, colon and rectum till it becomes slightly acidic or alkaline or *vice versa*. The paunch seems to be the transitional zone (KOVOOR 1967). In the present investigation, it has been observed that the pH of the gut tissues is higher than that of the gut contents. The pH of the gut tissues varied with the termite species investigated. The differences between the pH of the gut tissues and the gut contents are the maximum in *N. bosei* and the minimum in *S. cyclops*. These variations appear to be associated with differences in the food ingested and its mode of decomposition in the intestine. This observation thus confirms the views of WATERHOUSE (1949) and SRIVASTAVA & SRIVASTAVA (1956), that the pH of contents of the crop in insects roughly coincides with that of the food ingested.

It has been observed that the pH of the gut tissues, particularly in the hindgut, is acidic in lower termites (pH 6.2 to 6.6 in *N. bosei*), while it is alkaline in higher termites (pH 7.2 to 7.4 in *O. distans* and 7.6 to 7.9 in *S. cyclops*). This is probably an adaptation due to changes in food habit that have occurred in the lower and the higher termites This contention finds support in the observations of YONGE (1937) that the pH of the gut tissues in insects is generally at the pH optima of the specific digestive enzymes involved.

It has further been observed that the hindgut (paunch) is acidic in lower termites having symbiotic flagellates (*N. bosei*) but is alkaline in higher termites having bacteria as gut symbionts (*O. distans* and *S. cyclops*). This difference tends to suggest two distinct types of chemical reactions taking place in the paunch. KOVOOR'S (1967) observation that the pH of the paunch is almost neutral in both lower and higher termites is thus questionable.

It has been reported by SWINGLE (1931, for insects in general) and SRIVASTAVA & SRIVASTAVA (1961, for coleopterans) that the alimentary canal in insects is acidic. In the present investigation, acidic digestive canal has been observed only in *N. bosei*, the pH in *O. distans* and *S. cyclops* being alkaline. This finding thus differs from that of SWINGLE (1931) and SRIVASTAVA & SRIVASTAVA (1961) who have categorically stated that the alimentary canal in insects is acidic.

We have observed that the contents of the hindgut are acidic in *N. bosei* where the food is rich in carbohydrate and those in *O. distans* and *S. cyclops* are alkaline, the food being rich in protein. Thus the pH of the hindgut contents seems to be influenced by the type of food which the termites ingest. It may be noted that SWINGLE (1931) and GRAYSON (1951, 1958) have observed that the hindgut is usually more acidic than the midgut in phytophagous and carbohydrate consuming insects while the reverse is true in carnivorous and omnivorous insects. According to WIGGLESWORTH (1927) the microorganisms acting on carbohdyrates produce acidity, on protein alkalinity or nutral pH.

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SPERMATOPHORE DEPOSITION AND TRANSFER IN *PELOKYLLA MALABARICA*[1] (ACARI: ORIBATEI)

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This paper provides information on the spermatophores and their transfer in a species of oribatid mite for the firsr time from the oriental region. Adult males of *Pelokylla malabarica* deposit spermatophores within 10—15 days after their emergence. These are later taken by females into their genital pouch. Among the three factors affecting the rate of spermatophore deposition, availability of preferred food and presence of sufficient number of females in the neighbourhood promote spermatophore deposition while considerable reduction in moisture percentage adversely affects it. A single male produces a mean maximum of 27.8 spermatophores per day in the presence of females whereas in the absence of the latter the rate of production was only a mean of 7.4 per day.

(Key words: *Pelokylla malabarica*, spermatophore, morphology, biology)

INTRODUCTION

In the oribatid mites sperm transfer is accomplished mainly by the deposition of spermatophores into the external environment which are later transferred to the female genital pouch. The spermatophores are special containers which are often found to be of adaptive value in retaining the delicate sperms, without getting them dried up, till they are picked up by the females.

After MICHAEL'S (1884) initial observation, PAULY (1952, 1956), and TABERLY (1957) provided a better understanding of the nature of spermatophores of twenty species of oribatid mites. SENGBUSCH (1958, 1961), from his innumerable observations, confirmed sperm transfer through spermatophores as the usual method in these mites. SCHUSTER (1962), though noted an unusual behaviour, did not observe a free standing spermatophore. WOODRING & COOK (1962 a) studied spermatophore deposition in three species and explained (1962 b) the mechanism and the role of accessory glands in the formation of stalk substance. SCHLIWA (1965) doubted the possibility of the role of accessory glands in the formation of stalk substance in *Damaeus onustus*. LUXTON (1966) and CANCELA DA FONESCA (1969) contributed more information to our knowledge of oribatid spermatophores. WOODRING (1970), in his significant contribution on the comparative morphology, homologies and functions of the male reproductive system in oribatid mites, gave a good account of spermatophores of oribatids and explained in detail the mechanism of formation, deposition and also histochemical details of spermatophores by sectioning thirty species of male oribatids. SCHALLER (1971) and BUTCHER *et al.* (1971), in their reviews, compiled information on the spermatophores of many species of oribatid mites. SHEREEF (1971,

[1] This new genus is being described elsewhere.

1972, 1977) further contributed illustrated accounts of spermatophores of eighteen species of oribatid mites. CANCELA DA FONESCA (1975) added information on the spermatophores of three more species of oribatid mites. The biology of spermatophores of nine species of Liacaridae has been well studied by TRAVNICEK (1979).

MATERIALS AND METHODS

Mites for the study were obtained from the litter below cashew trees, *Anacardium occidentale* LINN. in the Calicut University Campus in June 1980. Live mites were reared in plastic culture chambers and their preferred food was noted as two species of fungi, *Pestalotia* sp. and *Stemphylium* sp. They were then maintained in special culture cells. A temperature of 28 ±2°C and a relative humidity of 85-90% were provided during the period of study. For spermatophore deposition a variety of substrates such as small pieces of cover slips coated with agar, charcoal and plant parts such as leaves, sepals, petioles, and twigs, were provided inside the culture cell. Soon after spermatophores were found deposited on these substrates, they were removed to clean cavity blocks containing 70% alcohol for 10-15 minutes and upgraded to 100% by carefully removing and introducing alcohol with a fine dropper. The slides were prepared by using the stains, viz., methylene blue, fast green, eosin, neutral red or basic fuchsin. The time given in each or these stains varied from 10-15 minutes depending on the clarity needed for observation. The foreign materials with stained spermatophores on them were held in between two slides. They were then subjected to the action of a fine fountain of alcohol repeatedly. During this treatment the spermatophores got separated, many with capsule intact and some with capsule detached from the pedicel. They were then mounted using PVA or Hoyer's medium following BAKER & WHARTON (1952). Spermatophores found deposited on the base of the culture chamber were removed with great care with a fine spatula and transferred to the cavity block, along with a portion of the plaster of Paris-charcoal base. The base, on treatment with alcohol, hardened and remained intact so that the presence of spermatophores could be located when passed through alcohol and stains. The spermatophores were also passed through graded series of alcohol, stained properly and mounted as before.

OBSERVATION AND DISCUSSION

The favourable conditions provided in the laboratory enhanced the production of large number of spermatophores in individual culture chambers. The newly emerged adult males (Fig. 1) were seen depositing spermatophores (Fig. 2) within 10–15 days. Even after taking great care, culture vessels got contaminated with undesirable fungi. In such a case it was often a problem to distinguish spermatophores from the sporangiophores of fungi (Fig. 3) due to their similarity in appearance.

i. Spermatophores and Sporangiophores : Spermatophores could be distinguished from sporangiophores by careful observation based on the following criteria. 1) The smooth and shining nature of the spermatophore capsule in contrast to the rough head of the sporangiophore. 2) The sporangiophores, unlike the spermatophores, were basally connected by horizontal hyphae. 3) Spermatophores were noted on the smooth culture chamber walls above the level of substratum but not sporangiophores. 4) The unique staining capacity of spermatophores.

ii. Nature of the freshly laid spermatophore: Freshly laid spermatophores appeared like dew drops (Fig. 4) when viewed from above. They were found keeping an erect posture in cultue chamber (Fig 5). The spermatophores were seen vertically on the substratum, on culture chamber walls but rarely on other materials provided in the culture chamber. Most of the spermatophores were seen on a bare substratum, singly or often in clusters of 2, 4, 7, 11 and 12. The straight stalk or pedicel (pedicle of TABERLY, 1957) (Fig 2) has an average length of 137μm. The spherical capsule, at the distal and of the pedicel, has a mean maximum width of 37.5 μm. TABERLY (1957) found the head

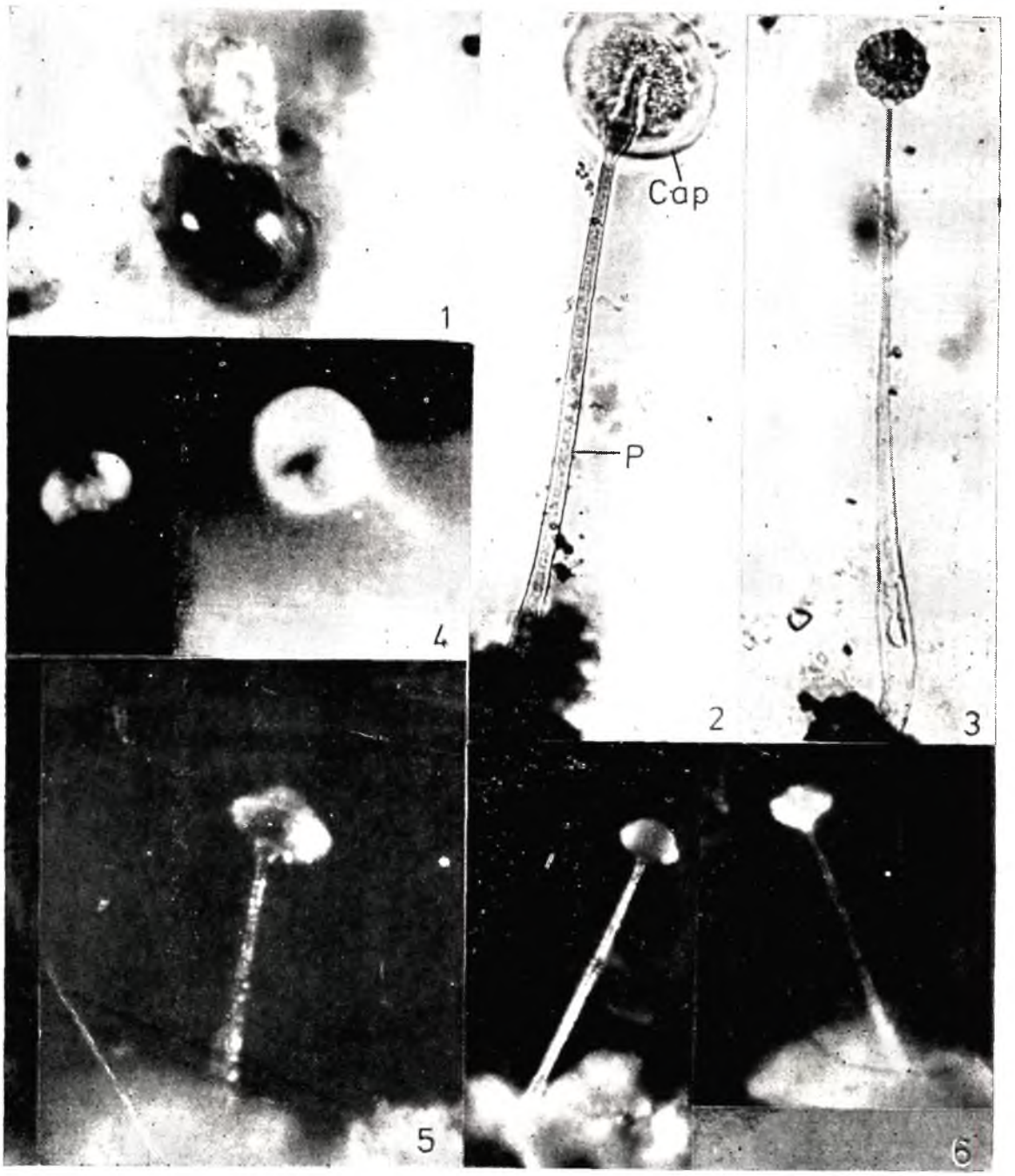

Fig. 1. Adult *Pelokylla malabarica* actively feeding on the fungus *Pestalotia* sp., × 100; Fig. 2. A free standing spermatophore of *P. malabarica* soon after deposition, ×1000; p. Pedicel, Cap. Capsule. Fig. 3. A sporangiophore of a fungal species resembling a spermatophore, ×1000; Fig. 4. Spermatophore in culture chamber appearing like dew drops, ×400; Fig. 5. A four day old spermatophore with the capsule resembling a hat, × 250; Fig. 6. One week old spermatophores with plaster of Paris-charcoal base. × 250.

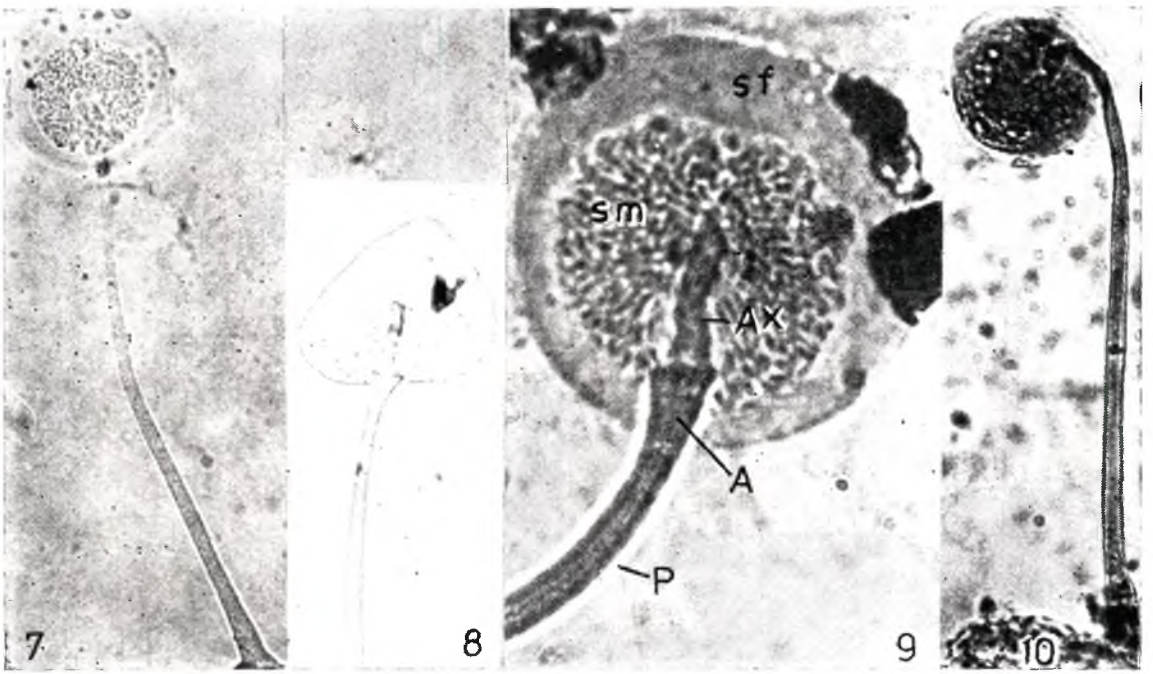

Fig. 7 A. fresh spermatophore showing the long tapering pedicel, × 1000. Fig. 8. Spermatophores showing basally flattened capsule, × 1000. Fig. 9. An enlarged view of the capsule of spermatophore, ×2500. P. Pedicel, A. Ampulla, Ax. Axil, Sm. Sperm Mass, Sf. Seminal Fluid. Fig. 10. Ten day old spermatophore with capsule drooping downwards, × 1000.

of spermatophores of the species he studied to be spherical except in *Steganacarus* sp. where it was transversely dilated and supported by a very short pedicle. The outer wall of the stalk appeared to be smooth while its inner granular part stained deeper. The stalk is broadened as an ampulla (Fig. 9), immediately before it enters the capsule and is extended into the capsule as the axil (Columella of TABERLY, 1957) (Fig 9) up to the middle of the former. Surrounding the axil was the mass of sperms (Fig 9) bounded by the region of seminal fluid.

iii. Post-deposition changes in the spermatophores: Close and continuous observation of spermatophores revealed the changes undergone by the spermatophores from the time of their deposition. They retained an erect posture and glittering appearance for the first one or two days and afterwards they were seen losing their glittering appearance and the upper portion of the stalk was slightly bent. During this time the shape of the capsule changed from spherical (Fig. 2) to conical (Fig. 5) with the formation of two depressions on either side. The shape of the capsule at this stage resembled a hat (Fig. 6). Later it became more flattened basally, the sperm mass getting condensed towards the base around the axil (Figs. 8, 11). A breakage plane is observed in between the ampulla and the capsule. This changed shape of the capsule and the breakage plane may facilitate the easy uptake of the spermatophore capsule into the genital pouch of the

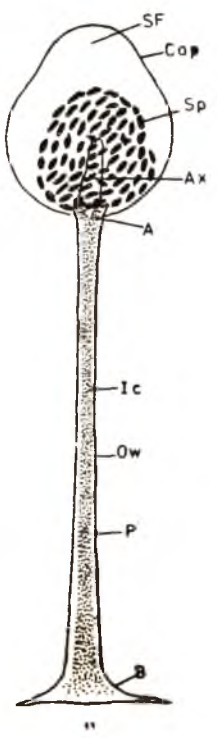

Fig. 11. An outline diagram of a four day old spermatophore of *P. malabarica*. B. Base, P. Pedicel, OW. Outer Wall, IC. Internal Core, A. Ampulla. Ax. Axil, SF. Seminal Fluid Sp. Sperm Mass.

female mite. About ten days after deposition most of the spermatophores were found to retain a slanting posture with capsule directed downwards (Fig. 10). At this stage the capsule was found easily detached and therefore transferring such spermatophores for preparation was difficult. Previous works in this field, already mentioned above, provide hardly any information on the post deposition changes in spermatophores.

iv. Spermatophore produciion: In the culture vessels, spermatophores were found deposited more during the early hours of the day, after 00 hrs but before 06 hrs. Possibly frequent observations under artificial light during the rest of the period might have adversely affected their normal production. In the laboratory though the adults could feed both on *Pestalotia* and *Stemphylium* species of fungi, spermatophores were seen produced only when they were offered a diet of the former. The adults were noticed to deposit spermatophores for few days continuously when provided with plenty of preferred food. When replenishment was not done the rate of production of spermatophores was seen greatly affected. Similarly the presence of females in the culture chambers appeared to influence spermatophore deposition. This was confirmed in the case of five males where the rate of sepermatophore production per mite per day was 27.8 when reared in the presence of females and only 7.4 when separately reared in the absence of females. Therefore availability of sufficient quantity of preferred food and the nearness of females favoured the production of spermatophore by these mites. The presence of females in the neighbourhood promoting spermatophore deposition was noted by SHEREEF (1972) in *Spatiodamaeus subverticillipes* which failed to produce spermatophore in the absence of females up to nine months but started depositing them after nine days in the presence of females. However TABERLY (1957) noted a single male of *Ceratoppia bipilis* producing a large number of spermatophores in the absence of females. When culture chambers were kept dry for a few days, only few spermatophores were produced by *Pelokylla malabarica*. This suggests the role of moisture in the rate of production of spermatophores. It was also observed that the rate of spermatophore deposition decreased as the mite grew older.

In the initial process of spermatophore deposition, the male was often noted to remain stationary for some time. The mite then exhibited a few rhythmic up and down movements and then raised its body. Subsequently it was found moving away, leaving behind the spermatophore on the substratum. TABERLY (1957) found *Ceratoppia bipilis* depositing spermatophores, twenty five days after the emergence of the adult and it continued up to two months without interruption. SHEREEF (1972, 1977) gave the average number of days between the emergence of the males and the onset of spermatophore production for twelve species which ranged from a minimum of three to a maximum of fifteen days. The commencement of spermatophore deposition within 10—15 days by fresh males of *P. malabarica* also falls within this range. The fact that no spermatophore was seen deposited on the fungal mycelium, the food of the mite, showed that the mites were somehow capable of feeling the nature of the substratum. PAULY (1956) also in his observation suggested the role of genital plates in feeling the ground before spermatophore deposition. The present study showed that *Pelokylla malabarica* preferred clean bare substratum for spermatophore deposition. This is contrary to the observation made by ARLIAN & WOOLLEY (1970) who found *Linacarus cidarus* periodically depositing spermatophores on the food material, the fungus *Cladosporium* sp. The rare presence of spermatophores on culture chamber walls confirms the necessity of getting a firm grip on the substratum for spermatophore deposition, which unlike the substratum of the culture chamber is very smooth and slippery. ROCKEIT & WOODRING (1966) observed an adult *Pergalumna omniphagus* eating spermatophores, which was confirmed by SHEREEF (1972) in the case of *Epidamaeus plumosus* also. Though large number of spermatophores were deposited by *Pelokylla malabarica* this type of curious behaviour was not observed in them.

v. Spermatophore transfer by the female: Females in many culture chambers were found actively moving in places where spermatophores were present. During this time the protruded genital organ and ovipositor were noted brushing against the spermatophore capsule. On several such occasions, the spermatophores on which the females moved over were noted to remain without capsule. Hence it was presumed that the capsule may have been carried by the females into their genital pouches during the aforesaid behaviour. The long ovipositor and widely opened genital organ may facilitate the easy uptake of the spermatophore capsule. Within 15—20 days after spermatophores were observed in culture chamber, oval creamy white eggs were seen deposited in the culture chambers.

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HISTOPATHOLOGICAL EFFECTS OF TEPA ON OOCYTE DEVELOPMENT OF THE TROPICAL HOUSE MOSQUITO, *CULEX PIPIENS FATIGANS* WIEDEMANN

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Treatment of *Culex pipiens fatigans* pupul stage with tepa, showed marked changes throughout the process of oogenesis. It caused significant reduction in the gross size, wet weight, dry weight and primary, secondary and tertiary follicles of the developing ovaries during the first gonotrophic cycle, as well as degeneration characterized by complete or partial breakdown of nurse cells, germaria, oocyte and follicular epithelia. Successive stages of tisssue degeneration were observed. The cells showed vacuolization and clumping of chromatin material which increased with lapse of time. Cytoplasm showed granular degeneration. The nuclei showed pycnosis. Yolk formation was inhibited.

INTRODUCTION

In female insects, the reproductive organs are visibly affected either as a direct effect or as an indirect effect of chemosterilants (LABREQUE & SMITH, 1968). Induced sterility in treated females may be because of the complete cessation of ovarian development, resulting in infecundity and non hatchability due to the presence of dominant lethals (BORKOVEC, 1966; LACHANCE, 1967; GROVER & PILLAI, 1972; CAMPION, 1972; WHITTEN & FOSTER, 1975; LABRECQUE & FYE, 1978).

In mosquitoes, alkylating agents caused drastic reduction in the size of the ovary due to the degeneration of follicles (MURRAY & BICKLEY, 1964; RAI, 1964 a, b; GROVER *et al.*, 1972; MATHEW & RAI, 1975). SUKUMAR & NAIDU (1973) and JALAJA & PRABHU (1976) observed similar reduction of the ovarian size at the gross level due to resorption of oocytes in *Dysdercus* after apholate treatment. In the developing follicles of *Ae. aegypti*, degenerative changes, such as condensation, pycnosis of the nuclei, vacuolisation of the cytoplasm and degeneration of follicular epithelium were reported by RAI (1964 a, b). GROVER *et al.* (1972) showed the degeneration of nurse cells and germaria in chemosterilized *C.p. fatigans*. MATHEW & RAI (1975) observed drastic alterations in the ultrastructure of nucleus and cytoplasm: nuclei showed condensation of chromatin, nucleolar fragmentation and abnormal appearance of nuclear envelope of ovarioles of *Ae. aegypti* after apholate treatment. Similar ovarian damage by alkylating chemosterilants has been observed in many insect species (SMITTLE *et al.*, 1966; BHARGAVA, 1975; JALAJA & PRABHU, 1976; SAXENA & ADITYA, 1976).

Apart from these studies little is known of the effects of tepa on gonads in *C.p. fatigans*. The present paper reports detailed study of the histopathological and

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morphological effects of tepa on the ovarian tissue of *C. p. fatigans*.

MATERIALS AND METHODS

The mosquito *C. p. fatigans* employed in the present investigation was drawn from a Delhi strain established and maintained in the laboratory since 1967 at 27°C ± 2°C and 75 ± 5 per cent RH. Newly emerged pupae were isolated, sexed and treated with 9000 ppm aqueous solutions of the chemosterilant tepa for 24 hr. This dosage was found to cause 100 per cent sterility in *C. p. fatigans*. Tepa (95—99 per cent pure) was obtained from Dr. A. B. BORKOVEC, U S D A, Beltsville, Maryland, U S A. The pupae were subsequently washed in water and were allowed to emerge in separate cages, fed with pigeon's blood at 48 hr after emergence. The ovaries of adults at different time intervals before and after blood meal were removed by dissecting the females in *Aedes aegypti* saline (HAYES, 1953).

Twenty five pairs of ovaries were collected and pooled in saline. They were weighed wet after carefully removing the saline adhering to the ovaries with the help of filter paper. For dry weight, 25 pairs of ovaries were homogenized in 2 ml of distilled water in a glass homogenizer. An aliquot of 0.1 ml sample of the homogenate was taken on a weighed aluminium foil, weighed and was kept in an oven at 80—90°C until it was completely dry and was weighed again. The difference between the two was taken as the dry weight of the sample and from this total dry weight of the ovaries was calculated. From the above data, the total mean dry weight of a pair of ovaries was calculated. Both the experiments were replicated five times, and mean and standard error per pair of ovaries were worked out.

Measurement of primary, secondary and tertiary follicles

The ovaries from treated and control females were collected separately in saline and transferred separately to small dishes containing lacto-aceto-orcein and were left covered for 2 hr at room temperature until the material was totally stained. Subsequently the ovaries were transferred to a cavity slide containing 60 per cent acetic acid, to avoid squashing. Follicles were separated with dissecting needles. The cover glass was sealed with DPX. After one hour follicles became uniformly stained. Then the follicles were examined without difficulty under a stereoscopic microscope. The length of primary, secondary and tertiary follicles was measured with a calibrated ocular micrometer.

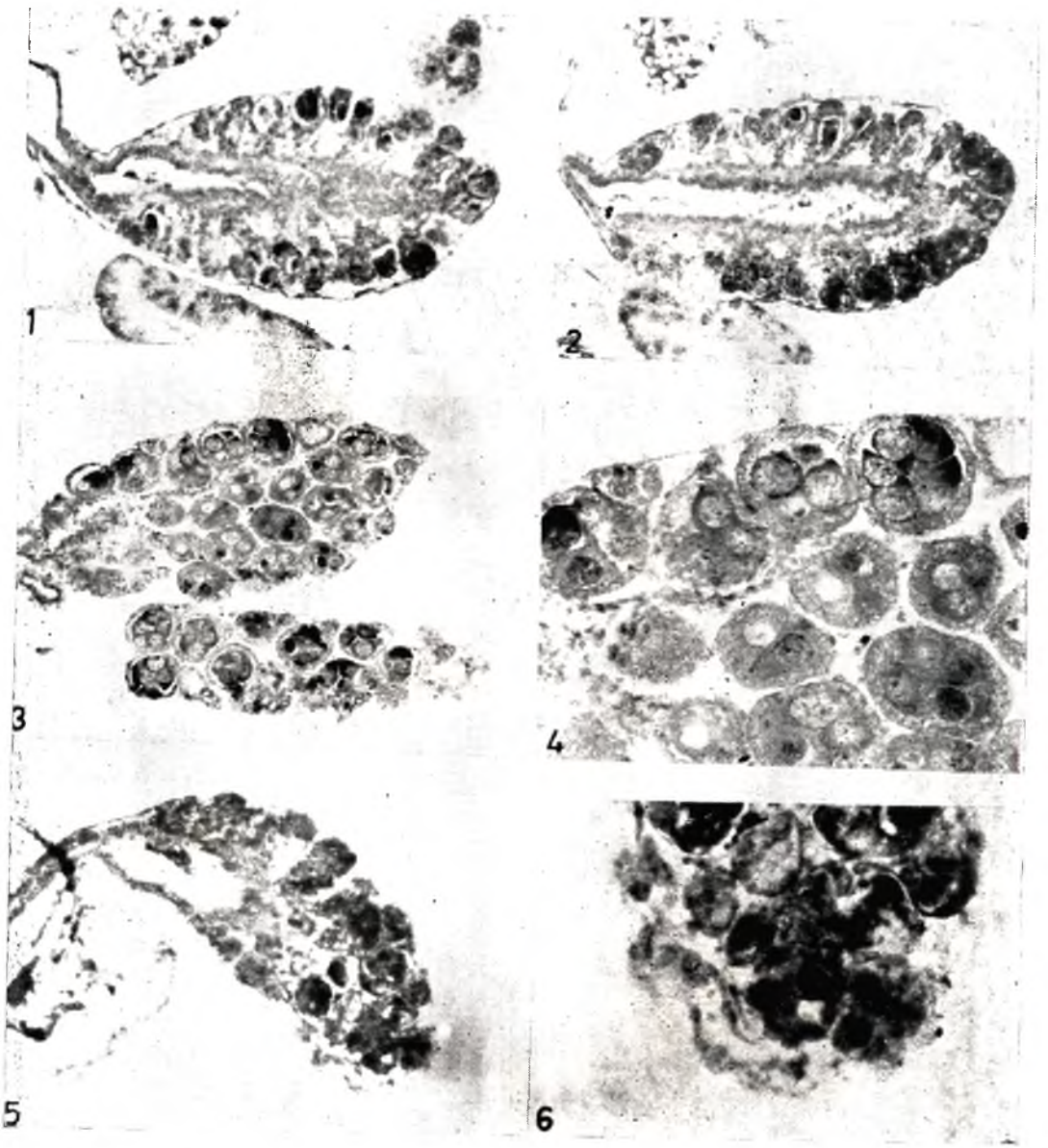
Histology of ovaries

Ovaries from treated and control females at different time intervals such as 24 hr before the blood meal (BBM) and also 12, 24, 36, 48, 60, 72, 84 hr after the blood meal were removed. They were immediately fixed in alcoholic Bouin's fluid for 24 hr, embedded in paraffin wax and sectioned at 10 μm. Sections were stained by Gomori's chrome - haematoxylin phloxine technique. Serial sections of normal and treated ovaries were studied and photomicrographs of the sections were taken.

RESULTS

When the females of *C. p. fatigans* were treated at pupal stage with 9000 ppm tepa, the ovaries were found to show marked changes from those of the normal ones throughout the process of oogenesis. It is clear from Table 1 that the size of the treated ovary was smaller than the normal at any developing stage. The normal ovary showed a gradual increase in the length and breadth, the maximum length and breadth observed were about 2485 μm, 1925 μm respectively at 60 hr after the blood meal whereas the length of the treated ovary did not exhibit a similar increase suggesting retarded development (Table 1).

The treated ovaries showed differences in their wet and dry weight as compared to the normal ones (Table 3). The wet weight of the normal paired ovaries of female showed steady increase and by 60 hr after the blood meal it became fifteen fold from the pre-blood meal stage (Table 3). However, the wet weight of the treated paired ovaries under identical condition increased only about nine fold. There



Figs. 1—6. Sections showing the effect of tepa on the ovaries of *C. p. fatigans*. Fig. 1. L. S. of normal resting ovary (just after emergence), × 100; Fig. 2. L. S. of tepa-treated resting ovary, × 100; Fig. 3. L. S. of normal ovary (24 hr after blood meal) showing a uniform arrangement of follicles × 100; Fig. 4. Enlarged view of normal ovary (24 hr after blood meal) showing synchronous development of follicles with nurse cells and follicular epithelium, × 400; Fig. 5. L. S. of tepa-treated ovary (24 hr after blood meal) showing a synchronous development of follicles, × 100; Fig. 6. Enlarged view of tepa-treated ovary (24 hr after blood meal) showing asynchronous development of follicles with degenerated nurse cells, × 400.

TABLE 1. The size of the ovary and primary follicles of tepa treated and normal females of *C. p. fatigans* at different time intervals.

Age of the mosquitoes	Size of ovary				No. of follicles (approx.)	Size of primary follicle			
	Length (μm)		Breadth (μm)			Length (μm)		Breadth (μm)	
	Normal	Treated	Normal	Treated		Normal	Treated	Normal	Treated
BBM[1] ABM[2]	656.67	560	212.31	175	50	72	70	35	35
12	925	903.3	454	438	72-80	159	70-140	62	52.5
24	1268.75	945.2	577.5	396.7	83	210	113.75	116.67	70
36	1586.67	980	610.62	472.25	85	224	126.9	132	100.43
40	1645	1050	793.33	450	88	236.25	135	166.25	105
48	1918	1400	847	430	90	258.75	140	153.25	110
60	2485	1062	1925	410	95	705.83	367.5	156.67	210
72	721	717.55	140	402.5	95	96.5	171.1	159	132

[1] Before blood meal.
[2] After blood meal (Blood meal provided at 48 hr after emergence).

was a seven fold decrease in the wet weight of the normal ovary after egg laying as compared to only a little decrease in the treated ovary. This coincided with less fecundity of the treated female.

Similarly, the dry weights of the normal and the treated ovaries were almost identical upto 24 hr old mosquitoes (Table 3). The dry weight of the normal ovaries by 60 hr after the blood meal showed four fold increase while that of the tepa treated ovaries showed only about 2.5 fold increase in their dry weight. After egg laying there was not much decrease in weight of the treated ovaries as compared to drastic reduction in the normal ones (Table 3).

In addition to differences in the size and weight of the normal and treated ovaries changes in the morphology and histology of their follicles were also observed and such changes were more prominent after the females were given blood. In the normal ovaries the development of the primary follicles was simultaneous and their size was uniform. In the treated ovaries the follicles showed irregular growth and reduction in the size of the primary follicles (Table 2). The treatment seemed to affect the secondary and tertiary follicles also. At 36 hr after first blood meal the treated secondary follicles were smaller in size than the normal ones and the tertiary follicles also were almost half the size of the normal tertiary follicle after the blood meal (Table 2).

Histological changes became apparent from the sections of the normal and treated ovaries. The resting ovaries (before the blood meal) of the treated females were almost identical to the normal ones (Figs. 1, 2). The sections of the ovaries 24 hr after blood meal showed normal development of follicles (Figs. 3, 4) as compared to the treated ones in which concentration of follicles on one side was observed (Figs. 5, 6). In the 36 hr old follicles, the yolk

TABLE 2. Effect of 9000 ppm tepa on pre-vitellogenic and post-vitellogenic development of primary, secondary and tertiary ovarian follicles of *C. p. fatigans*.

Time after adult emergence in hr	1st blood meal			[1]2nd blood meal after 1st egg laying			
	No. of females	Condition of primary follicles	Length (μm) of secondary follicles	No. of females	Condition of primary follicles	Condition of secondary follicles	Length (μm) of tertiary follicles
12 hr treated	20	Degenerated	53.2 ± 6.8	20	Degenerated	Degenerated	52.3 ± 7.5
Normal	20	Mature	108.7 ± 7.9	20	Relic	Mature	104.3 ± 4.6
24 hr treated	20	Degenerated	51.4 ± 6.4	20	Relic	Degenerated	54.5 ± 7.0
Normal	20	Mature	105.9 ± 4.2	20	Relic	Mature	101.5 ± 6.1
36 hr treated	20	Degenerated	61.2 ± 5.8	20	Relic	Degenerated	52.5 ± 6.9
Normal	20	Mature	102.8 ± 5.4	20	Relic	Mature	107.4 ± 3.1
48 hr treated	20	Degenerated	50.2 ± 6.2	20	Relic	Degenerated	51.4 ± 8.1
Normal	20	Mature	106.1 ± 5.1	20	Relic	Mature	100.9 ± 7.8
72 hr treated	20	Degenerated	52.8 ± 4.7	20	Relic	Degenerated	62.8 ± 7.2
Normal	20	Mature	109.4 ± 2.1	20	Relic	Mature	106.12 ± 1.45

[1] Second blood meal provided to differernt batch females which completed the first egg laying.

TABLE 3. Wet and dry weight of the ovaries in females of *C. p. fatigans* treated as pupae with 9000 ppm tepa (*in vivo*) for 24 hr.

Age of the female mosquitoes in hr	Wet weight (μg / pair of ovaries)		Dry weight (μg / pair of ovaries)	
	Normal ± SE	Treated ± SE	Normal ± SE	Treated ± SE
24 hr BBM[1]	141 ± 0.45	139 ± 1.30	72 ± 0.59	70 ± 0.54
0-1 hr ABM[2]	145 ± 1.05	144 ± 1.23	85 ± 0.55	84 ± 1.45
12	170 ± 1.87	170 ± 2.03	128 ± 1.71	119 ± 1.59
24	901 ± 1.08	810 ± 3.20	160 ± 1.67	152 ± 2.67
36	1250 ± 1.54	830 ± 3.86	181 ± 2.07	171 ± 2.53
48	1330 ± 2.86	858 ± 3.24	210 ± 2.81	173 ± 2.77
60	2050 ± 3.60	950 ± 4.75	256 ± 1.59	178 ± 3.84
72	2150 ± 3.60	1200 ± 2.11	286 ± 2.03	180 ± 1.92
84	305 ± 1.28	1000 ± 4.50	89 ± 1.39	158 ± 1.14

[1] Before blood meal

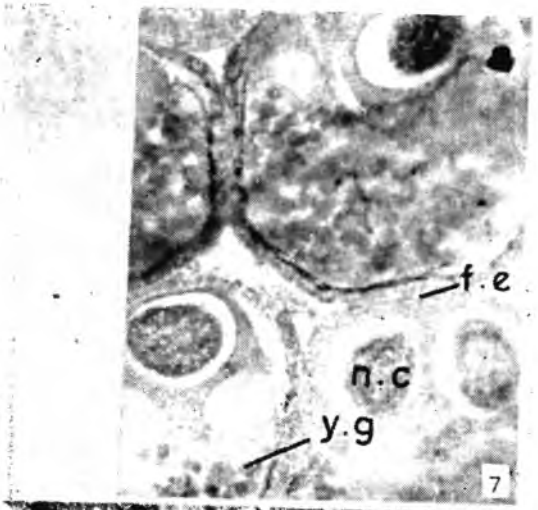
[2] After blood meal (Blood meal provided at 48 hr after emergence).

was highly vacuolised and the yolk granules were scattered (Fig. 8). Because of the loss of compactness in the yolk, the bounding epithelium was crumpled, unlike that in normal follicles where the follicles were firm and rounded (Fig. 7). The follicular epithelium did not show distinct cells throughout the gonotrophic cycle. The nurse cells of the treated ovary also showed degeneration and had clumped chromatin in many follicles (Fig. 8). The follicles of 40-48 hr old ovaries after the blood meal appeared very different from the normal follicles (Figs. 9, 11, 13). Besides vacuolisation, the yolky area had lost its granular appearance indicating towards the formation of new vacuoles (Figs. 10, 12, 14, 15). Only a few follicles of the treated ovary were fully developed in size at 60 hr but they had degenerated germarium, broken epithelium and sparsely scattered yolk granules (Fig. 17) unlike the normal eggs which were filled with granular yolk and had firm follicular epithelium (Fig. 16).

Figs. 7—10. Sections showing the effect of tepa treatment on the ovaries of *C. p. fatigans*. 7. T. S. of normal primary follicles (36 hr after blood meal) showing oocyte filled with granular yolk and the nurse cells with distinct nuclei, × 1000. 8. T. S. of tepa-treated primary follicles (36 hr after blood meal, showing vacuoles in yolk and the nurse cells with clumped chromatin, × 1000. 9. T. S. of normal primary follicles (40 hr after blood meal) completely filled with granular yolk, × 400; 10. T. S. of tepa-treated primary follicles (40 hr after blood meal) with vacuoles and degenerated yolk, × 400; 11. T. S. of normal primary follicle (40 hr after blood meal) filled with granular yolk, × 400; 12. T. S. of tepa-treated primary follicle (40 hr after blood meal) showing degeneration of yolk granules, × 400.

ABBREVIATIONS

c. c—clumped chromatin in nucleus; d. f. e—degenerated follicular epithelium; d. y. g—degenerated yolk granules; f. e.—follicular epithelium; n. c.—nurse cells; vac.—vacuole; vac. f. e.—vacuoles in follicular epithelial cells; y. g.—yolk granules.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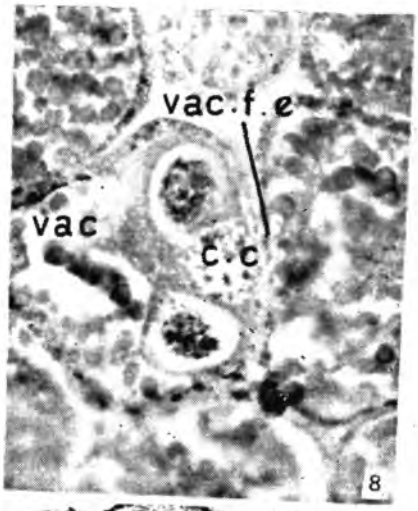
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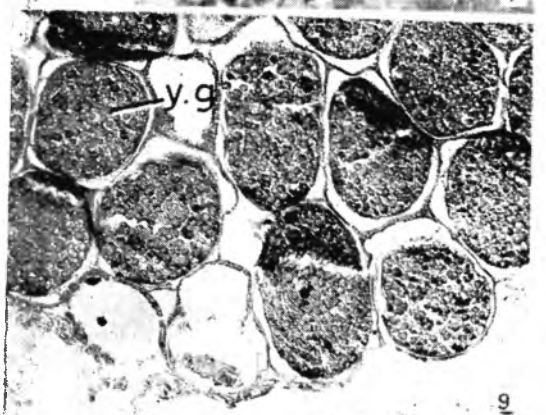
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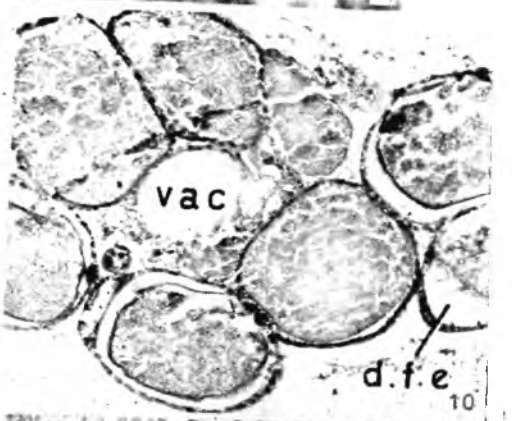
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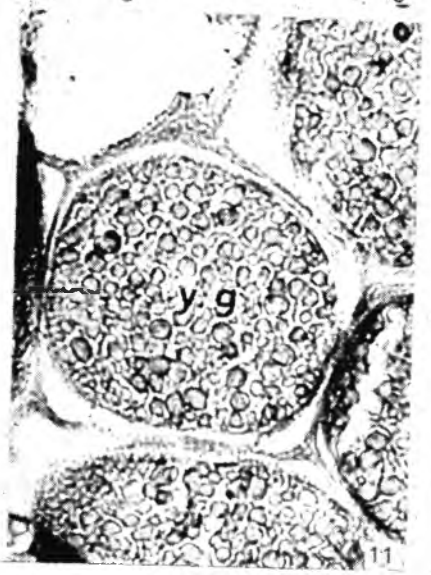
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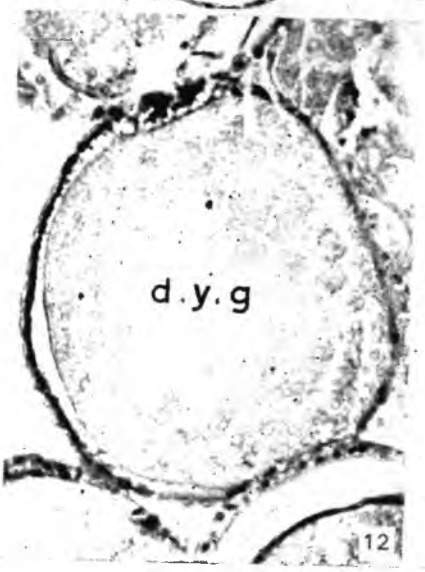
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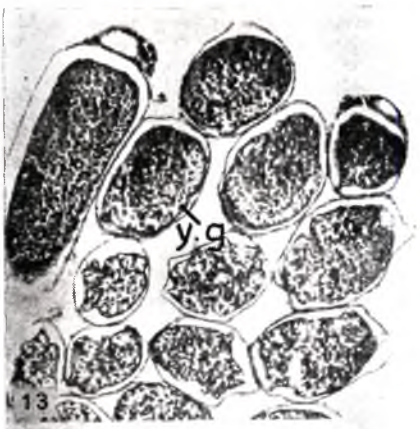
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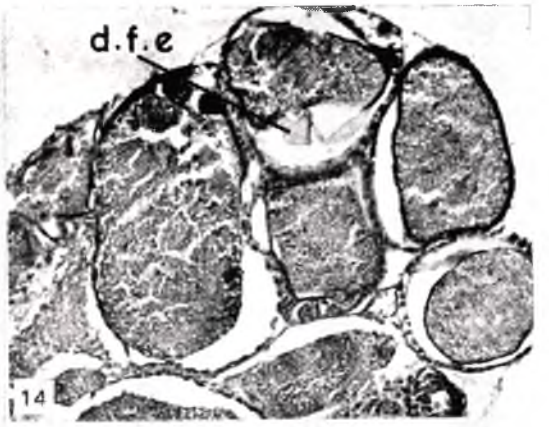
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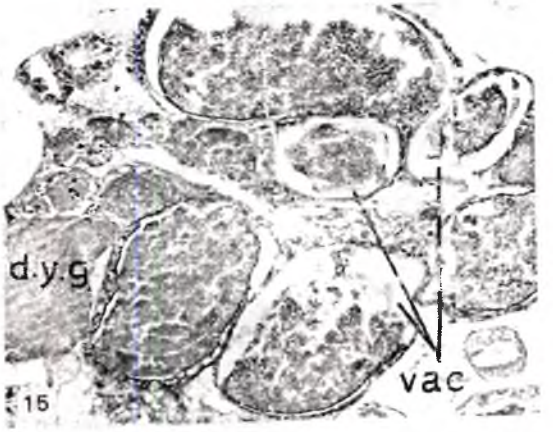
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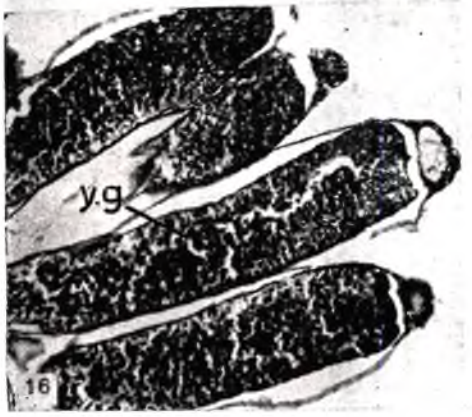
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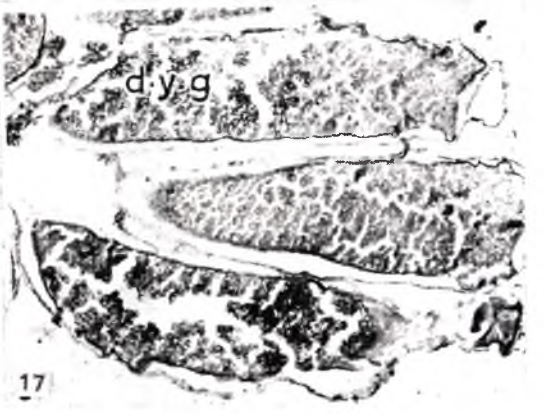
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DISCUSSION

In *C. p. fatigans* pupal treatment of tepa caused significant reduction in the gross size of the ovaries in the female at 96 hr after emergence. It was also found that the wet and dry weights of the ovaries of the treated females were less than that of the controls but there was a steady increase in wet and dry weight of the treated ovaries during the gonotrophic cycle though at a lower level. Normal ovaries showed considerable reduction in their wet and dry weights immediately after egg-laying unlike the treated ovaries where there was no decrease in the weight of the ovary. This evidently coincides with reduced fecundity of the treated females as compared to normal. Reduction in the gross size of ovaries of *C. p. fatigans* to alkylating agents also exhibited reduction in the size of the ovaries (BERTRAM, 1963; MURRAY & BICKLEY, 1964; RAI, 1964a; GROVER *et al.*, 1972). Similar reduction in the size of the ovaries of houseflies was reported after treatment with apholate, metepa or tepa (MORGAN & LABRECQUE, 1962, 1964; LANDA & REZABOVA, 1965; ABASA, 1968; LANDA & MATOLIN, 1971), and of *D. melanogaster* after treatment with apholate (CANTWELL & HENNEBERRY, 1963). LACHANCE & LEVERICH (1968) found drastic changes in the size of ovaries in *C. hominivorax* after treatment with alkylating agents. Morphological changes in the developing ovaries as evident from overall decrease in size were noticed after apholate treatment in cockroach (SMITTLE *et al.*, 1966; BHARGAVA, 1975). Apholate and metepa caused reduction in the number of oocytes as well as decreaee in the size of ovary in *D. cingulatus* (JALAJA & PRABHU, 1976).

The data presented here also showed that the tepa-treated ovaries of *C. p. fatigans* had fewer number of primary, secondary and tertiary follicles and the developing follicles showed various degrees of degeneration characterized by complete or partial breakdown of nurse cells, oocyte and follicular epithelia unlike in normal ovaries. It was also observed that in treated females, follicular development was asynchronous and that some of the follicles were deformed. Earlier, in *C. p. fatigans* it was found that the follicles of females lacked secondary follicles or germaria after treatment with tepa and metepa (GROVER *et al.*, 1972). MURRAY & BICKLEY (1964) observed severe abnormalities in the follicles of *C. p. quinquefasciatus* after apholate treatment. MATHEW & RAI (1975) reported changes in the ultrastructure of ovarian tissue after treatment with substerilizing doses of apholate in *Ae. aegypti*, where majority of follicles underwent degeneration as their nuclear envelope was disrupted in several places. When apholate, tepa or metepa were fed to female houseflies from emergence till sexual maturity, only oocytes in first egg

Figs. 13—17. Sections showing the effect of tepa-treatment on the ovaries of *C. p. fatigans*. 13. T. S. and L. S. of normal eggs (48 hr after blood meal) full of granular yolk, × 400; 14. T. S. and L. S. of tepa-treated egg (48 hr after blood meal) with vacuolization in yolk, × 400; 15. T. S. of tepa-treated ovary (60 hr of blood meal) with follicles showing degenerated yolk granules and follicular epithelium, × 400; 16. L. S. of normal eggs (60 hr of blood meal) with granular yolk and firm follicular epithelium, × 400; 17. L. S. of tepa-treated eggs (60 hr of blood meal) with vacuolized yolk and degeneration of germaria, follicular epithelium, × 400.

ABBREVIATIONS

d. f. e.—degenerated follicular epithelium; d. y. g.—degenerated yolk granules; vac.—vacuole; y. g.—yolk granules.

chamber reached maturity while that of 2nd and 3rd egg chambers failed to develop (MORGAN & LABRECQUE, 1962, 1964).

The visible histo-pathological effects of tepa on ovarian tissue of *C. p. fatigans* became evident 24 hr to 36 hr after blood meal. The cells of the follicular epithelia showed vacuoles in their cytoplasm, nuclei were deformed and chromatin in the nuclei of the nurse cell clumped in irregular masses. The effects became more apparent in ovarian follicles 48 hr after blood meal resulting in vacuolization and degeneration of yolk granules. Degeneration of follicles has also been observed in *Ae. aegypti* and *Anopheles gambiae* after treatment with thiotepa (BERTRAM, 1963). Similar changes in follicles causing condensation and pycnosis of the nuclei, vacuolization of the cytoplasm and general atrophy were reported in *Ae. aegypti* follicles treated with apholate (RAI, 1964 a, b). GROVER *et al.* (1972) reported cytogenetic damage in the nurse cells and germaria after treatment with alkylating agents in *C. p. fatigans*. MATHEW & RAI (1975) showed that in *Ae. aegypti* apholate treatment suppressed follicular development and at high doses the follicular differentiation was completely inhibited. It also caused striking changes in the ultrastructure of ovarian tissue such as condensation of chromatin in the nuclei, nucleolar fragmentation and abnormal appearance of nuclear envelope accompanied with complete degeneration of organelles. Similar degeneration of nurse cells and germaria after treatment with tepa or apholate was also observed in cockroach (SMITTLE *et. al.*, 1966; BHARGAVA, 1975). SUKUMAR & NAIDU(1973), and JALAJA & PRABHU (1976) reported various degenerative changes in the pre-follicular and follicular tissues and, occurrence of multiple oocytes within a single follicle without any linear arrangement of oocytes in the ovarioles of *Dysdercus* after apholate treatment.

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CARBOFURAN AND ITS METABOLITES IN RICE PLANTS TREATED AT DIFFERENT GROWTH STAGES AND ITS RELATION WITH THE TOXICITY TO *NILAPARVATA LUGENS* STAL[1]

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Carbofuran (furadan 3G) was applied @ 1.08 kg ai/ha to paddy plants at 15, 30, 45 and 60 days after transplantation. The samples of leaves and stem collected at 1, 3, 7, 14 and 21 days after treatment were analysed for pure carbofuran and 3-OH carbofuran residues. The toxicity of these residues to brown planthopper nymphs were simultaneously assessed by confining the test insects on the leaves and stem portions of the plant.

It was seen that insecticides get translocated to leaves and stem within 24 hours after application. From 3rd to 7th day the carbofuran content decreased while the metabolite recorded an increase. Then both declined and reached insignificant levels on 21st day. The carbofuran content of the leaf and stem showed direct correlations with the mortality of BPH nymphs while there was no relationship between 3-OH carbofuran content and insect mortality.

INTRODUCTION

Carbofuran is widely used for controlling the pests of crops like sorghum, sugarcane, potato, tobacco, banana, cotton, vegetables and is claimed to give protection for 4-6 weeks (AGNIHOTRUDU & MITHYANTHA, 1978). It is also recommended against brown planthopper, *Nilaparvata lugens* STAL., which occurs as a serious pest at all growth stages of paddy crop. The translocation of carbofuran to the different parts of the plant and its relationship with the mortality caused to brown planthopper nymphs confined to the stem and leaves of the plant was studied by conducting a field-cage experiment.

[1] Part of the M. Sc. (Ag.) thesis of the Senior author presented to Kerala Agrl. University, Trichur, Kerala State, India.

MATERIALS AND METHODS

The experiment was conducted in field cages (3m × 3m) filled with silty loam soil (pH 4.5). Paddy (Thriveni of 100 days duration) was sown and the crop was treated at five different growth stages (15 days after sowing and 15, 30, 45 and 60 days after transplantation) with carbofuran (furadan 3G) @ 1.08 kg ai/ha. Each treatment was replicated thrice and a Randomised Block Design was adopted. Samples were collected at 1, 3, 7, 14 and 21 days following each treatment and the leaves and stems were analysed separately for its carbofuran and 3-OH carbofuran contents by adopting thin-layer chromatography (GUPTA & DEWAN, 1976). Technical grade carbofuran and its 3-OH metabolite obtained from FMC corporation, New York was used for the studies. Samples for bioassay were taken from control and treatment plots. Three tillers each taken along with roots and soil were placed in specimen tubes. Six such replications were taken from each plot. Three of them were used for exposing nymphs of *N. lugens* on the stem portion and 3 for exposure to the leaves.

The stem portion was enclosed in glass tube plugged with cotton around the stem at both ends after introducing the insects. The leaf portion was enclosed in chimneys supported above the stem level with a card board slit and passed around the stem. Cottonwool was placed around the stem to prevent the downward migration of the nymphs. The chimney was then closed with muslin cloth. Fifteen 3rd instar nymphs were confined in each replication and the mortality was recorded at the end of 72 hours.

RESULTS AND DISCUSSION

The residues of pure carbofuran in the plants reached the maximum levels within 24 hours after application and from the 3rd day onwards, there was a decrease in the carbofuran residue levels while the metabolites recorded a steady increase. The decrease in pure carbofuran contents corresponded the increase in the metabolite upto the 7th day after application. But on subsequent occasions there was decrease of pure carbofuran as well as 3-OH carbofuran. Higher quantity of the insecticide was seen translocated to the leaves than to the stem in all growth stages of the crop (Table 1.)

TABLE 1. Mortality of nymphs of *N. lugens* corresponding to residues of carbofuran in the leaves and stems of rice plants treated at different growth stages of the crop.

Growth stages	Intervals in days	Leaf			Stem		
		Pure carbofuran	3-OH carbofuran	% Mortality	Pure carbofuran	3-OH carbofuran	% mortality
15 days after sowing	1	3.19	0.26	100.00	1.30	0.45	60.00
	3	2.03	0.41	100.00	0.92	1.01	23.30
	7	0.65	1.16	63.30	0.39	1.14	10.00
	14	0.53	0.52	40.00	ND	0.82	0.00
	21	0.35	4.67	10.00	ND	1.11	0.00
15 days after transplanting	1	3.36	0.56	100.00	1.61	0.37	80.00
	3	2.13	0.93	93.30	1.03	0.77	60.00
	7	2.13	0.93	56.70	0.39	1.36	3.30
	14	0.52	0.23	30.00	ND	0.95	0.00
	21	0.24	0.22	0.00	ND	0.61	0.00
30 days after transplanting	1	3.67	0.76	100.00	1.05	0.55	83.30
	3	2.33	1.17	100.00	0.88	0.78	43.30
	7	0.47	2.83	46.67	0.37	1.10	33.30
	14	0.39	0.90	33.33	ND	0.43	13.00
	21	0.12	0.46	6.17	ND	0.42	0.00
45 days after transplanting	1	2.82	0.29	100.00	0.92	0.37	63.30
	3	2.02	1.59	93.30	0.83	0.43	40.00
	7	0.78	2.18	53.30	0.44	0.96	10.00
	14	0.46	1.55	33.39	0.37	0.46	0.00
	21	0.25	0.50	10.00	ND	0.51	0.00
60 days after transplanting	1	1.99	0.43	100.00	0.78	ND	56.10
	3	1.78	0.74	95.30	0.50	0.33	33.00
	7	0.38	2.07	50.00	0.38	0.65	17.22
	14	0.34	1.78	32.67	ND	0.60	0.00
	21	0.11	1.13	6.00	ND	0.30	0.00

ND—Non-dectetable.

Bio-assay studies showed that if the nymphs were allowed to feed only from the leaves, it resulted in cent per cent mortality on the first day of application of the insecticide. When permitted to feed only from the stem, which is the usual habitat of the hoppers, the mortality caused was very low. Feeding on the stem caused 56.66 to 83.30% reduction of the insects only. The mortality of the nymps registered a rapid decrease from the 7th day of application.

The translocation of the insecticide to the stem and leaves as evidenced by the contents of carbofuran and 3-OH carbofuran and mortality caused to *N. lugens* was not seen affected by the different growth stages of the crop. Comparison of the values of pure carbofuran residues both in leaves and stem with the corresponding mortality values showed that decrease in pure carbofuran contents corresponded to the decrease in the mortality levels. There was a significant positive correlation between these ($r = 0.9$). These studies showed that estimation of total carbofuran in plant parts may not give a correct picture of the persistent toxicity of the insecticide to BPH since it will include metabolites like 3-OH carbofuran. 3-OH carbofuran is known to be 1120 times less toxic to *Musca domestica* than carbofuran (METCALF *et al.*, 1968).

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OBSERVATIONS ON THE BIOLOGY OF A RHEOBIONT CADDISFLY *RHYACOPHILA OBSCURA* MARTYNOV (RHYACOPHILIDAE : TRICHOPTERA)

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Observations on the biology of Rhyacophila obscura Martyov, a free-living, predatory caddisfly have been described. This low temperature lotic form was studied wih respect to egg-laying, differentiation of the five instars, pupation, emergence and mating of adults, and some interesting observations have been recorded.

(Key words: biology, *Rhyacophila obscura)*

INTRODUCTION

The biology of caddisflies has been studied by numerous workers, notably ANDERSON (1974) on *Agapetus fuscipes*, ELLIOTT (1971) on *Apatania muliebris*, and HANNA (1961) on several British genera. OSWOOD (1976) and MACKAY (1978) recently studied the biology of some Hydropsychids. RESH (1976) contributed to biological studies on *Cerclea* (Leptoceridae). The Rhyacophilid genera, however, have been neglected in this respect. No specific attempt has been made so far to study the biology of any of the caddisflies abundant in India.

MATERIAL AND METHODS

The observations on the biology of *Rhyacophila obscura* Martynov were mainly restricted to the upper reaches of the Beas Valley, popularly known as the Kulu valley (Himachal Pradesh), in the drainage area of R. Beas. Stations were selected along the banks of the Beas River and its tributaries Manalsu Nullah and Ahlni Nullah, at Manali and its environs. These stations were frequently visited at regular intervals. The adults of this species were reared within rectangular mesh-cages placed over the stones in the river bed and were also collected with the aid of a Petromax light trap at night.

RESULTS

Rhyacophila obscura MARTYNOV represents a characteristic low temperature, lotic form among caddisflies. Predominantly, it is found in the upper reaches of R. Beas and is also encountered during winter months at lower altitudes in the river. This species is free-living and predatory in nature. The larval stages were found feeding upon mayfly nymphs and some dipteran larvae present on the submerged stones.

Egg laying Egg laying was observed only on two occasions, once in June 1976 and again in June 1977. Some females with a whitish, rounded egg-mass enveloped in a gelatinous secretion, attached to the underside of the abdominal tip, were found skating over the surface of the least disturbed water near the river bank. After a short while, a few of these females crawled under the water along the surfaces of submerged stones and remained submerged for about one to one and a half minutes, before resurfacing without their egg-masses. These females obviously selected

a sheltered spot on the submerged stones near the banks in the water and attached their egg-masses before resurfacing. A large number of gelatinous egg-masses attached to the downstream sides of the submerged stones were observed. MOSELY (1933) mentions an air bubble enclosing the female in some species. A similar observation on *Agapetus fuscipes* is recorded by ANDERSON (1974). This air bubble was not observed on *Rhyacophila obscura* females.

Larval stages. The larval forms of this species live among stones and crawl about actively, leaving a trail of silk produced by the labial glands in their wake. They are frequently found on the exposed surfaces of rocks in search of food. The larvae do not build any sort of home or case. Anal prolegs are stout and well developed, enabling the larva to hold on to and to move over the rocks and to afford anchorage to the larva at the posterior end, allowing free lateral movements of the abdomen. The throax is comparatively longer than in tube dwelling forms.

An analysis of the immature stages collected from the stations during 1975, 1976 and 1977 reveals the presence of five well defined instars. The sizes and the distinguishing features of each instar are given in Table.

Pupation and emergence. This species has two generations a year in the R. Beas, though their life-cycles appear to be overlapping at different collection spots. This observation is substantiated by the availability of pupal stages at almost all the stations throughout the year. However, the majority of the pupal stages were observed during March and June.

The free-living final instar larva, before undergoing pupation, locates a suitable spot and constructs a cup-shaped pupal enclosure of large fragments of stone of

TABLE 1. Representing sizes and distinguishing features of different larval instars of *Rhyacophila obscura* MARTYNOV.

Stadium	Length in mm (average of 10 specimens)	Distinguishing features
First instar	9.0	Body cylindrical, thorax and abdomen with long setae and cream in colour.
Second instar	12.5	Body cylindrical, thorax and abdomen with long setae and yellowish cream in colour.
Third instar	16.5	Body somewhat flattened, thorax and abdomen with comparatively smaller setae; colour yellowish cream with purplish dorsal surface.
Fourth instar	19.6	Body ventrally flattened but convex dorsally and thorax and abdomen with prominent inter-segmental constrictions and light purplish brown in colour.
Fifth instar	22.0	Body ventrally flattened with thorax and abdomen convex dorsally and purplish brown in colour with deep intersegmental constrictions.

various sizes and shapes, glued together by a silken secretion. The free edge of the cup-like pupal enclosure is attached to a large submerged stone, generally on its trailing edges. Within this enclosure, a tough chestnut-coloured pupal case is formed within which the larva pupates. By the end of the pupation period, the stony enclosure gradually starts falling apart, probably to help in the easy escape of the subimago, after emergence from the pupal case. On emergence the subimago rises to the surface of the water by paddling actively with the help of the highly setaceous forelegs. On reaching the surface, it is carried downstream for a short distance before it succeeds in climbing on to an exposed rock surface. After securing a hold on the surface, it runs restlessly in all directions exposed rock for a short while before undergoing the final moulting. Immediately on moulting the adult takes to air and seeks shelter under the stones and pebbles, along the dry banks of the stream. The adults of this species are generally nocturnal and are attracted to petromax lamp light at night.

Mating. Mating was invariably observed at night with the help of a flash light. Both the male and female emerge from their underground shelters, enter into copulation on the upper surface of the stones, generally avoiding the direct impact of the wind current. On being disturbed by the flash light the copulating pairs run about on the surface of the stone to avoid the glare of the light and escape into the darkness. The duration of the copulation, however, could not be observed.

DISCUSSION

The observations recorded in this paper are of particular interest as they represent a pioneer attempt to study the biology of caddisflies in India. Even in other countries the rhyacophilid genera have so far been neglected.

In the light of the knowledge available in literature, the following peculiarities of rhyacophilid biology emerged during this study.

The air bubble associated with egg laying females as recorded by MOSELY (1933) in some spp. and by ANDERSON (1974) in the case of *Agapetus fuscipes*, was not observed by the author in the case of *Rhyacophila obscura*. The feeding habits are typically rhyacophilid, this species being a free-living, carnivorous form which feeds on small mayfly and dipteran larvae. Similar food habits have been reported in the case of *Rhyacophila dorsalis* by HICKIN (1967).

It was very difficult to observe mating in the nocturnal adults which managed to escape immediately on being disturbed by light. HICKIN (1953) however, has given an account of mating in *Mystacides nigra*.

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EFFECTS OF TEMPERATURE ON β-GLUCOSIDASE ACTIVITY RHYTHM IN *HALTICA CAERULEA* OLIVIER (COLEOPTERA : HALTICIDAE)

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Temperature sensitivity of β-glucosidase rhythm in the digestive extract of *Haltica caerulea* Olivier is demonstrated. A bimodal activity rhythm with peaks at 09 and 21 hours was obtained under laboratory conditions with 12 L:D cycle. Entrainment of this rhythm by two sublethal temperatures, 37 C and 15 C indicated temperature sensitivity of β-glucosidase rhythm with both a phase shift and change in the amplitude. High temperature induction is favourable since the pattern remains to be bimodal with peaks at higher level whereas low temperature is harmful with complete loss of rhythmicity, decreased food intake and low enzyme activity.

(Key words: β-glucosidase rhythm, bimodal rhythmicity, *H. caerulea* Olivier; temperature induction of rhythm, Q_{10} and glucosidase rhythm.)

INTRODUCTION

Effect of temperature on endogenous rhythms vary in different insects and act at different temperature range depending upon the temperature scale of each species and the photoperiod (BENTLY *et al.*, 1941; BROWN & WEBB, 1948; CLOUDSLY-THOMPSON, 1953, 1957; STEPHENS, 1957; BUNNING, 1958). Temperature scale of each species consists of a broad range, in which the rhythm pattern of natural periodic responses are not affected, and a comparatively narrower range on either side of the former in which the pattern is affected partially or completely.

Entrainment of feeding rhythm and other activity rhythms by temperature has been widely studied when compared to that of enzymic patterns. As the digestive enzymes play an important role in feeding efficiency of the species, studies on rhythmic patterns of these enzymes would be useful.

It has been shown in *H. caerulea* OLIVIER that a temperature range 20-31 C is most favourable for the insect and the temperatures above or below this would be sublethal (unpublished data). As the temperature of the natural environment of *Haltica caerulea* varies between 14-38 C, they are exposed to lethal and sublethal temperatures at least once in its life cycle.

In the present investigation, the normal feeding pattern of *Haltica caerulea* is correlated to β-glucosidase rhythm and its entrainment by temperature is studied.

MATERIALS AND METHODS

Adult *H. caerulea* from their semiaquatic habitat near suburbs of Bangalore, India, were housed in the laboratory in well aerated wooden cages and fed with the host plant, *Jussiaea repens*. All experiments were conducted at 25±1°C, 60% RH unless otherwise stated.

β—glucosidase rhythm and its entrainment by temperature : 3 batches of 100 adults each of

Haltica caerulea OLIVIER from the first laboratory generation were maintained under 12 L:D conditions in climatic chambers at 25±1°C, 37±1°C and 15±1°C respectively. These were supplied with 40W bulbs from an external source and the switch off and on at 6.00 PM and 6.00 AM was done manually. Adults were supplied with the food plant *ad libitum*.

Ten adults each from each of these three batches were removed at 03°°, 06°°, 09°°, 12°°, 15°°, 18°°, 21°° and 24°° hours and dissected in cold. The alimentary canals removed were washed with cold distilled water and homogenised to a final concentration of 2% in the cold distilled water. The supernatant obtained after centrifuging this at 10,000 rpm for 10 minutes at 0°C is used as the enzyme source.

β—glucosidase activity was determined according to the method of OKADA (1968). The reaction mixture contained 0.5 ml of 0.0316 M *p*—nitrophenyl β-D glucoside, 1 ml of 0.1 M acetate buffer, pH 4.8 and 0.5 ml of the homogenate containing the enzyme. After incubation at 37°C for 30 minutes, 0.5 ml of this mixture was added to 10 ml of 0.1 N sodium carbonate and the liberated *p*-nitrophenol was estimated from extinction at 420 $m\mu$ using Spectronic 20. Standard graph was prepared using *p*-nitro phenol and the enzyme activity expressed in terms of mg *p*-nitrophenol liberated/mg protein/minute. Enzyme protein was determined by the method of LOWRY *et al.* (1951).

RESULTS AND DISCUSSION

Fig. 1 (a) represents the pattern of *p*-nitrophenyl β-D glucosidase activity rhythm of digestive extract of *H. caerulea* OLIVIER at 12 L : D, 25 ± 1°C and 60% rh. There are two peaks, at 09°°, 21°° hr respectively showing that the rhythm is bimodal with a period of 12 hr. Similar 12 hr periodicity was obtained for feeding and amylase rhythm in *H. caerulea* (KASTURI BAI *et al.*, 1975).

Bimodal rhythmic patterns are reported for flight activity of mosquito *Anopheles gambiae* (JONES *et al.*, 1967, 1972), *Aedes taeniorhynchus* (NAYAR & SEUERMAN, 1971) and of tsetse fly, *Glossina morsitans* (BRADY, 1972). The two interpretations provided for the bimodal nature of the rhythm are that two temporarily displaced types of individuals must be present in the sampled population, each of which display only one period of activity per photoperiodic cycle and that each individual of the population may display a daily rhythm with two or more periods of activity.

On temperature induction the rhythm pattern persists indicating that the latter possibility is more probable than the former.

Fig. 1 (b) is the pattern of rhythm obtained at 37°C. Thermal entrainment was induced at 03°° hr and it is observed that the first peak remains at the same position whereas the second peak is shifted to the right and appears at 15°° hr. Both the peaks are higher when compared to that at laboratory temperature. The first peak has the Q_{10} of 1.9 and the second 2.8. On the second day, the first peak flattened out and the second remains the same. On the third day the rhythm attains a new pattern with smaller peaks at 6°° hr and a higher peak at 15°° hr respectively with 9°° hr interval.

At 15°C (Fig. 1 c) on the first day the first peak remained at the same position but with a Q_{10} of 1.8 and the second peak had a shift of 3 hr to the right and the activity at this hour is more or less the same. On the second day there is great inhibition of the activity of the enzyme and the peaks more or less disappear with their fragmentary peaks at 03°° and 15°° hr respectively. On the third day the activity is very low and the pattern loses its rhythmicity with the complete disappearence of the peaks.

Results indicate that the temperature brings about both phase shift and the

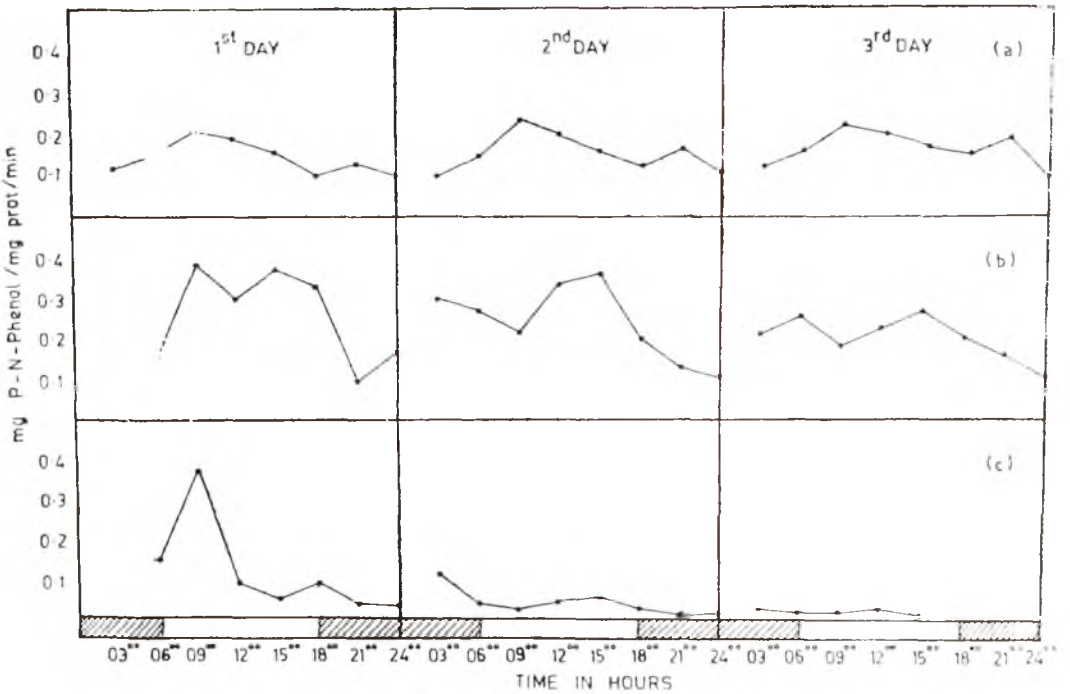

Fig. 1. Effect of temperature on β-glucosidase activity rhythm in *Haltica caerulea* OLIVIER a) Laboratory temperature, 25±2°C; b) 37°C and c) 15°C.

entrainment of natural rhythm of enzyme activity in *H. caerulea*. In addition it influences the height of the peak with the Q_{10} ranging between 1.8 to 2.8 indicating that the effect may primarily be due to the effects of temperature on the rate of chemical reaction as indicated by ARRHENIUS. High temperature induction is favourable to *H. caerulea* since the feeding pattern remains to be bimodal with increased peaks but at different times of the day. On the other hand low temperature (15°C) seems to be harmful, since there is complete loss of bimodal rhythmicity of feeding which means to say that there is low food intake with decreased enzyme activity.

Unlike in *Haltica caerulea* where both the phase shift and a change in the amplitude of the rhythm is observed, in all other organisms so far investigated, the period of the rhythm was relatively unaffected by temperature though their amplitude showed a normal physiological temperature dependence (BROWN & WEBB, 1948; KAYSER & MARX, 1951). However similar phase shifts at different temperatures were noticed for the larval activity rhythm in *Halisidota argentata* (EDWARDS, 1964).

According to BUNNING (1958) each rhythm may consist of two temperature dependent cycles with 12 hr interval, one being cold dependent and the other heat dependent. If the animal is subjected to cold during heat dependent period or *vice versa*, the rhythm becomes temperature dependent. The observed temperature dependence of β-glucosidase rhythm in *H caerulea* with changes in both the phase pattern and the amplitude of the rhythm would accordingly be due to continuous exposure of the animal to

induced temperatures irrespective of its phase sensitivity.

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DESCRIPTION OF A NEW GALLERIID, *LAMORIA HEMI* (LEPIDOPTERA: GALLERIINAE, PYRALIDAE) FROM NORTH INDIA

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Out of the five species of Subfamily Galleriinae, collected from North India, four species viz., *Galleria mellonella* (Fabricius), *Achroia grisella* (Fabricius), *Corcyra cephalonica* (Stainton) and *Ashwania reniculus* Pajni and Rose, are already known. The remaining fifth species, is a new species and it is referable under the genus *Lamoria* Walker, named as *L. hemi* sp. nov.

(*Key words*: galleriid, *Lamoria hemi*, Pyralidae)

In the course of an extensive collection survey of the moths of family Pyralidae from North India, the author collected five species belonging to the subfamily Galleriinae. These five species included two new species, one of which has already been published (Pajni & Rose, 1977). The second species, according to Hampsonian key (1896), is clearly referable to the genus *Lamoria* Walker. The species under reference is prominently different from all other species described in the genus *Lamoria* by Hampson (1896, 1917), Ragonot and Hampson (1901) and Whalley (1964), and hence is being declared as a new species. It is, however, allied to *L. pallens* Whalley but drastically differs in the shape of uncus and the arrangement of spines on its surface are quite different. It is, therefore, described as new and is named as *Lamoria hemi* sp. nov.

Lamoria hemi sp. nov. (Figs. 1—7)

Head: Vertex furnished with pale ochreous scales; frons rounded, with a prominent tuft of pale ochreous scales, irrorated with brown. Antenna shorter than the forewing; scape brown, tinged with fuscous flagellum covered with fuscous scales. Eye pitch-black; with a row of ochreous and fuscous scales behind. Ocellus absent. Labial palpus of male reduced, hidden below the frontal tuft, that of female porrect, down-curved at extremity, extending beyond head length, covered with fuscous scales, irrorated with pale-ochreous and grey scales. Maxillary palpus filiform, covered with jet-black scales. Proboscis reduced. Posterior margin of head enormously clothed with ochreous brown scales.

Thorax: Fusco-piceous, irrorated with grey and dull ochreous; pale ochreous ventrally.

Fore wing: Costal margin arched beyond middle, apex rounded; termen straight and oblique; tornus rounded; anal margin nearly straight. Ground colour fuscous, irrorated with grey and ochreous brown; male with a glandular swelling of scales at base on costa; anterior margin densely suffused with fusco-piceous; a circular black mark with ill-defined grey centre

present on discocellulars; veins with fuscous streaks; margin with a series of dark black specks; marginal fringe fuscous brown, with fusco-piceous line. Discal cell more than half the length of wing; cell closed, R_1 free, from well before anterior angle of cell; R_2 free; R_3, R_4 and R_5 stalked; M_1 straight; M_2 and M_3 from the same point in male and on a long stalk in female; Cu_1 from before lower angle of cell in male and from cell in female; Cu_2 at less than two-third the length of cell; 3A looped at base of 2A.

Hind wing: Costal margin straight; apex produced at Rs; termen obliquely curved; tornus rounded; anal margin straight. Ground colour pale brownish, suffused with fuscous at costal and outer margins; veins with fuscous streaks; margin with white streak; marginal fringe grey, with a fuscous line. Discal cell open. Rs fused with $Sc+R_1$ beyond cell for some distance; M_2, M_3, Cu_1 and Cu_2 on a common stalk and at regular intervals distally; three anals present.

Legs furnished with fuscous scales; prothoracic coxa, the femur, the tibia and the tarsi densely and uniformly suffused with fusco-piceous scales; mesothoracic coxa, femur and the tibia suffused with fusco-piceous; mesothoracic tibia with the outer spur exactly one-third the length of inner in male, outer spur of anterior pair on hind tibia slightly less than one-third the length of inner and that of posterior pair extremely poorly developed; outer spur of mid tibia and that of anterior pair on hind tibia slightly less than half the length of inner spur in female, hind tibia with outer spur of distal pair exactly one-third the length of inner.

Abdomen covered with exceptionally very minute and brown coloured scales on dorsal surface and with ochreous scales on ventral surface.

Male genitalia: Uncus short, tapered to a rounded point distally, uniquely adorned with short spines and partially setose; gnathos absent; tuba analis much shorter than uncus; scaphium absent; subscaphium moderately developed; tegumen well sclerotized; vinculum almost V-shaped; saccus rudimentary. Valva long, somewhat unsymmetrically rounded distally; costa broadly inflated, marked by thin line on inner side; sacculus differentiated; harpe absent. Transtilla just rudimentary; juxta well sclerotized. Aedeagus moderately long and slender, with both walls sclerotized; vesica with a well defined long cornutus along with a few spines at proximal end of cornutus, the latter surrounded on either sides with loosely arranged denticles.

Female genitalia: Corpus bursae more or less rounded, membranous, except with a few sclerotized lines; signum absent; ductus bursae long, with well defined walls; anterior apophyses very long and thin; poste-

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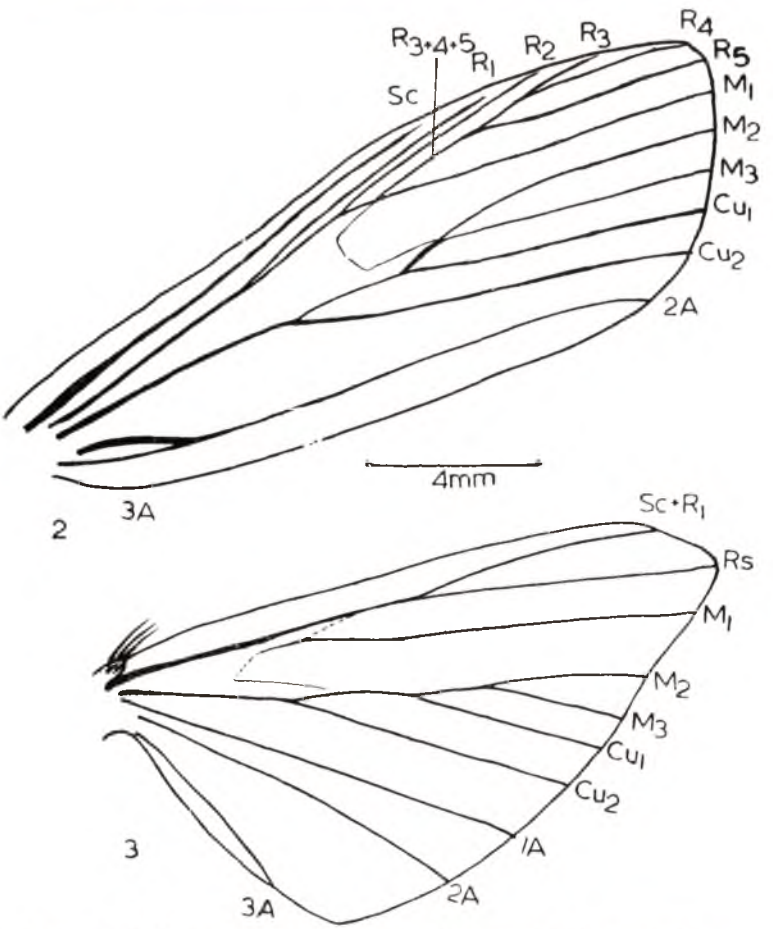
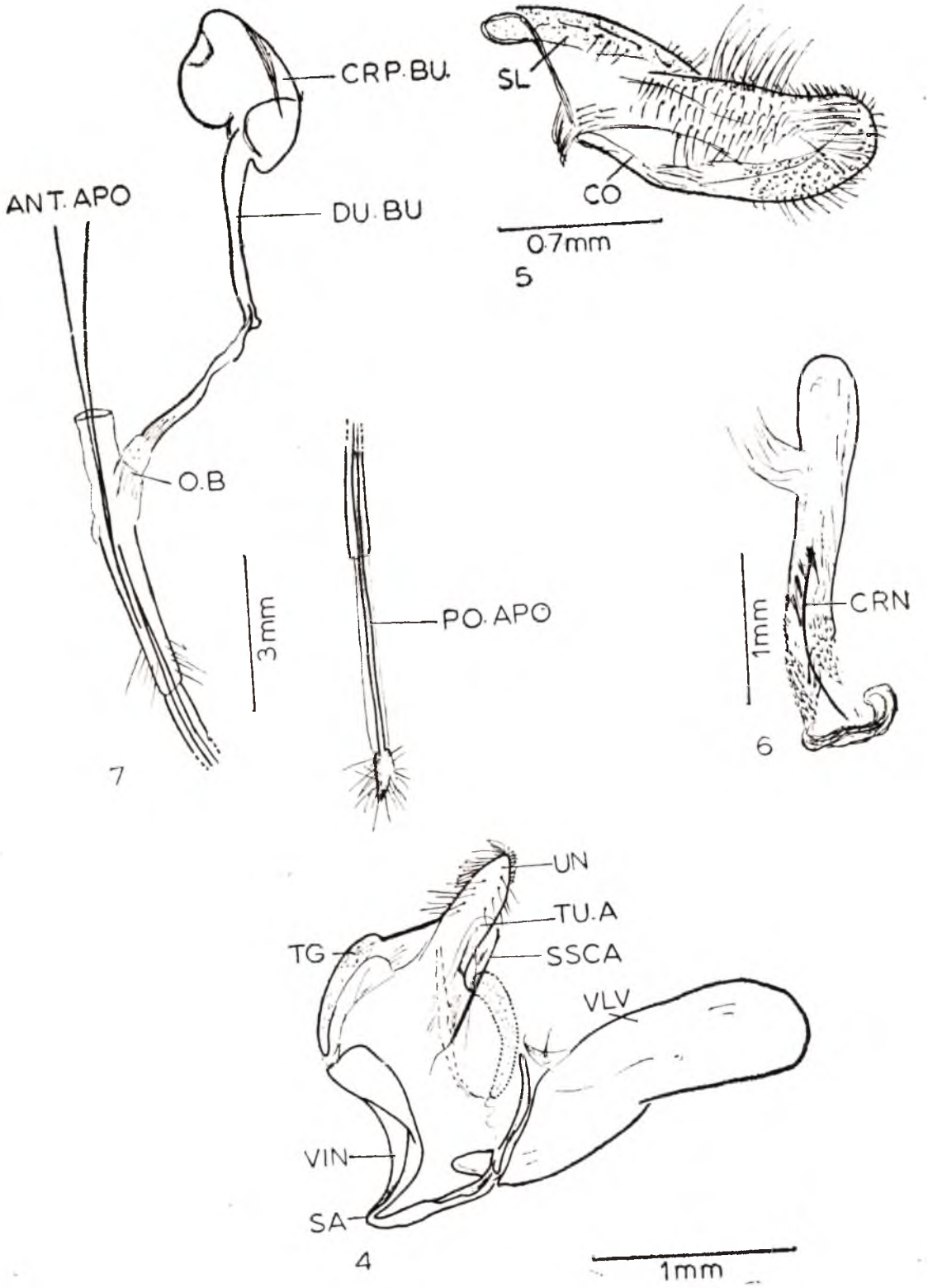
ABBREVIATIONS

1A—First anal vein; 2A—second anal vein; 3A—Third anal vein; ANT.APO—Anterior apophyses; CO—Costa; CRN—Cornutus; CRP.BU—Corpus bursae; Cu_1—First cubital vein; Cu_2—Second cubital vein; DU. BU—Ductus bursae; M_1—First median vein; M_2—Second median vein; M_3—Third median vein; O. B.—Ostium bursae; PO.APO—Posterior apophyses; R_1—First radial vein; R_2—Second radial vein; R3—Third radial veln; R_4—Fourth radial vein; R_5—Fifth radial vein; R_{3+4+5} Stalk of R_3, R_4 and R_5; RS—radial sector; SA—Saccus; Sc—Subcosta; $SC+R_1$—Subcosta + R_1; SL—Sacculus; SSCA—Subscaphium; TG—Tegumen; TU.A—Tuba analis; UN—Uncus VIN—Vinculum; VLV—Valva.



Figs. 1—7. *Lamoria hemi* sp. nov. 1. Photograph of the adult; 2. Forewing; 3. Hind wing; 4—6. parts of male genitalia; 7. Female genitalia.


CRP.BU.
ANT.APO
DU.BU
O.B
3mm
7
SL
CO
0.7mm
5
PO.APO
1mm
CRN
6
UN
TU.A
TG
SSCA
VLV
VIN
SA
4
1mm

rior apophyses longer than anterior apophyses: ovipositor relatively reduced, densely, setose.

Alar expanse: Male : 32.5 mm to 40 mm.
Female : 43 mm to 45 mm.

Holotype: ♂ INDIA: UTTAR PRADESH Dehra Dun, 'light', Sept., 1975, Coll. H. S. Rose. **Allotype** ♀ Same data as holotype.

Paratypes: 4 ♂ ♂, 1♀. One male and one female paratype collected in Sept. 1977, otherwise same data as holotype and allotype. (All type series are deposited with Dr. H. R. Pajni, Dept. of Zoology, Punjab University, Chandigarh, where author's main collection is displayed).

The species is named in honour of late Dr. Hem Singh Pruthi, who retired as Plant Protection adviser to the Government of India.

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Entomon, **1981**, *Vol.* **6**, *No.* 2, *pp.* 173 *to* 174

A NEW SPECIES OF *CINARA CURTIS* (HOMOPTERA : APHIDIDAE) FROM NORTHWEST INDIA

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&

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(Received 25 August 1980)

A new species of aphid *viz.*, *Cinara chaetorostrata* collected from Simla, Himalayas, Northwest India, is described.

(Keywords: aphid, new species, Northwest India)

Cinara chaetorostrata, sp. nov. (Fig. 1)

Alate viviparous female: Body 4.14—4.80 mm long with about 1.80—2.10 mm as maximum width near middle of abdomen. Head and thorax blackish. Dorsal cephalic hairs long and fine (about 130 μm). Antennae 6-segmented, 0.41—0.43 times as long as body, segments I and II dark brown; flagellum brownish except the distal part of segments III, IV and V which are darker: processus terminalis 0.30—0.33 times as long as base of antennal segment VI; flagellar hairs (Fig. 1A) about 65μm—247μm long, the longest one on segment III up to about 4.5—5.0 times as long as basal diameter of antennal segment III; antennal segment III with 2—4, IV with 2—3 and V with 1—2 large tuberculate secondary rhinaria at distal end of each segment; segment VI with 6 accessory rhinaria. Eyes large with small triommatidia. Rostral segments 4+5 (Fig. 1B) 0.40—0.42 mm long and about as long as or a little longer than second joint of hind tarsus, reaches 3rd coxae: segment 4 with about 21 short and long secondary hairs besides 3 preapical pairs. Abdominal tergum pale, bearing small scattered sclerites; dorsal hairs about 130μm—169μm long and on anterior tergites about 2.5—3.2 times as long as basal diameter of antennal segment III. Siphunculi on dark brown hairy cones whose basal diameter about 0.32 mm and pore about 0.09 mm. Cauda dark, sclerotic. Legs dark but pale on basal half of femora: tibial hairs long with acute to acuminate apices (Fig. 1C); tarsi with numerous long and fine hairs. First tarsal segment with 11 hairs. Wing venation typical for *Cinara*; media once-branched, faintly marked: pterostigma elongate, brown; radial sector reaching apex of forewing: veins light brown.

Measurements (in mm) of the holotype: Length of body 4.80, width 1.90; antenna 1.98; antennal segments III 0.68, IV 0.32, V 0.37, VI (0.22+0.07); ultimate rostral segment 0.42; second joint of hind tarsus 0.43; secondary rhinaria on antennal segments III 4 & 3, IV 2 & 3, V 2 & 2, VI 6&6.

Holotype: Alate viviparous female, INDIA: HIMACHAL PRADESH: Kufri, on wing,

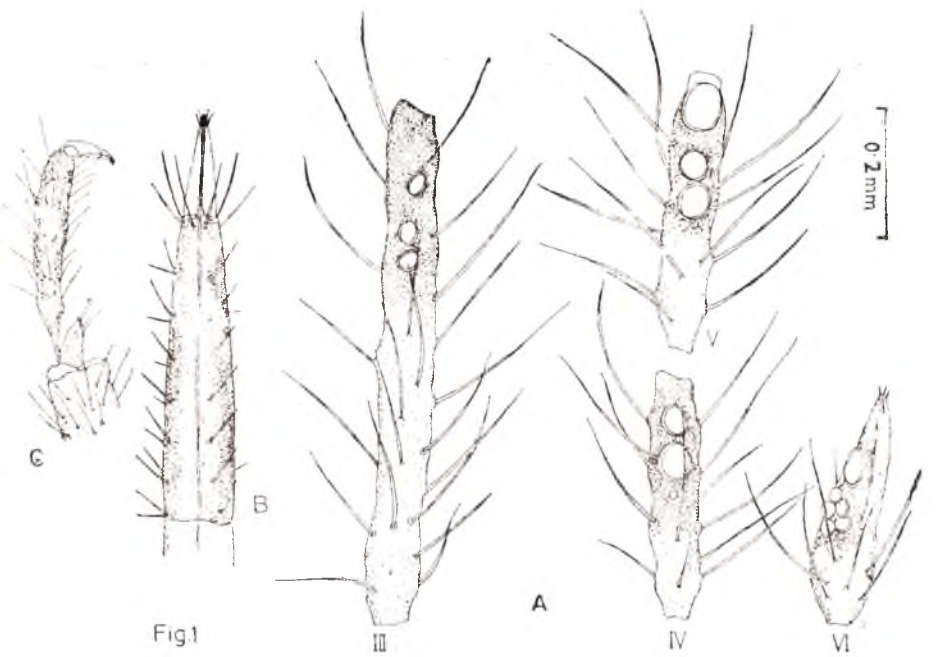

Fig 1. A—C. *Cinara chaetorostrata*, sp. nov.; Alate viviparous female: A. Antennal segments III-VI; B. Ultimate rostral segment; C. Hind tarsi with portion of tibia

15. xii. 1973 (coll. L. K. Ghosh), **Paratype:** Alate viviparous female, same data as for holotype. (In the Collection of the Zoological Survey of India, Calcutta).

Biological note: The dark brown alate aphids were collected dead on snow at an elevation of *C* 2500 metres.

Distribution: The species is hitherto known only from Himachal Pradesh.

Remarks: Following Eastop (1972), *Cinara chaetorostrata*, sp. nov. approaches close to *C. kochiana* (Börner) in having many hairs on rostral segment 4, but the new species can easily be separated from the latter by much longer flagellar and body hairs. In having long flagellar and body hairs, the new species resembles *C. comata* Doncaster collected "on Snow" from Tehri-Garhwal Himalayas, India but differs in having much longer rostral segments 4+5 and many secondary hairs on rostral segment 4 besides other characters.

Acknowledgement: One of the authors (L. K. Ghosh) expresses his gratitude to the Director, Zoological Survey of India, Calcutta for the laboratory facilities.

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Entomon, 1981, *Vol.* **6**, *No.* 2, *pp.* 175 *to* 177

BRIEF COMMUNICATION

FIELD RECOVERY OF *EUCELATORIA* SP. NEAR *ARMIGERA* (COQ.) (DIPTERA : TACHINIDAE) FROM *HELIOTHIS ARMIGERA* (HUBN.) (LEPIDOPTERA : NOCTUIDAE) IN KARNATAKA, INDIA

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(*Received 25 August 1980*)

Field releases of *Eucelatoria* sp. near *armigera* (Coq.) a larval endo-parasite have been made against *Heliothis armigera* (Hubn.) in Bangalore district (Karnataka). The parasite has been recovered four times from the fields showing signs of its establishment in Bangalore district against *H. armigera* infesting tomato, beans and arhar to afford biocontrol of the pest.

(*Key words:* field release and recovery, *Eucelatoria*, *Heliothis*)

Heliothis armigera (HUBN.) is a serious cosmopolitan polyphagous pest in the tropics and subtropics. *Eucelatoria* sp. near *armigera* (COQ.) a larval endoparasite of *H. armigera* originating from the U S A was obtained through the Indian Station of the Commonwealth Institute of Biological control by the Directorate of Plant Protection, Quarantine and Storage for biocontrol trials against *H. armigera* in India (SANKARAN & NAGARAJA, 1979). The following is a brief account of the releases and successful biocontrol attempts made by the Central Biological Control Station, Bangalore in Karnataka.

Field release and recovery surveys:

Eucelatoria sp. was mass-multiplied in the laboratory on the larvae of *H. armigera* as described by SANKARAN & NAGARAJA (1979). For field trials, mated females after completion of their gestation period were released or to ensure parasitism, the larvae of *H. armigera* were collected from the test field, parasitised by *Eucelatoria* and again released in the same field. From January, 1979 to April, 1980 a total of 1,560 *Eucelatoria* flies and 798 parasitised larvae (by *Eucelatoria* sp.) were released in Bangalore district (Table 1) (Annual Report, Directorate of Plant Protection, Quarantine and storage, 1979 and 1980). The significant results achieved are as follows:

During January 1979, a quarter acre field with a mixed crop of arhar and beans was found infested with *H. armigera* at Chikkajala in Bangalore district. Thirty larvae were collected from this filed, parasitised by *Eucelatoria* and again released. Ten mated females were also released. After a fortnight, i. e., on 17-1-1979, another 30 larvae at random were collected and kept for observation in the laboratory. Five of these larvae were found parasitised and a total of nine flies were obtained from them in the laboratory.

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TABLE 1. Showing field releases of *Eucelatoria* sp. near *armigera* (COQ.) for the biocontrol of *Heliothis armigera* (HUBN.) in Banglore district (Karnataka).

Sl. No.	Date of release	Number released		Crop	Place
		Adults	Parasitised larvae of *H. armigera* by *Eucelatoria* sp.		
1.	3-1-79	—	30	Beans	Kodigehalli
2.	3-1-79	—	30	Arhar	Chickkajala
3.	3-1-79	10	—	Arhar	Chickkajala
4.	12-1-79	—	20	Beans	Kodigehalli
5.	12-1-79	—	30	Arhar	Chikkajala
6.	17-1-79	—	20	Tomato	Kodigehalli
7.	17-1-79	100	—	Arhar	Chikkajala
8.	9-3-79	150	—	Potato	Chickkaballapur
9.	9-3-79	—	54	Potato	Chickkaballapur
10.	16-3-79	—	54	Tomato	G K V K Cross
11.	16-3-79	—	20	Potato	Chickkaballapur
12.	6-4-79	75	—	Tomato	Doddajala
13.	28-6-79	—	50	Tomato	Veswaswarapura
14.	28-6-79	—	25	-do-	Boodihal
15.	6-7-79	50	40	-do-	-do-
16.	10-7-79	—	30	-do-	-do-
17.	18-7-79	20	—	-do-	-do-
18.	4-8-79	50	—	-do-	-do-
19.	10-8-79	80	30	-do-	Bellandur
20.	21-8-79	60	10	-do-	-do-
21.	13-9-79	150	40	-do-	Vadudevpura
22.	26-10-79	100	55	-do-	Veshwaswarapura
23.	30-10-79	75	45	-do-	-do-
24.	7-11-79	—	35	-do-	-do-
25.	7-11-79	—	20	-do-	Kachanahalli
26.	16-11-79	50	—	-do-	Veshwaswarapura
27.	20-11-79	150	—	-do-	-do-
28.	6-12-79	100	20	-do-	Devahahalli
29.	13-12-79	100	—	Beans	Veshwaswarapura
30.	22-12-79	—	15	-do-	Arishanakunte
31.	22-12-79	—	25	-do-	K B Sandra
32.	28-12-79	—	70	-do-	-do-
33.	24-1-80	—	30	Tomato	Nelamangala
34.	30-1-80	50	—	-do-	Nellandur
35.	14-2-80	50	—	-do-	Hessarghatta
36.	22-2-80	70	—	-do-	Gulakmale
37.	20-3-80	70	—	-do-	-do-
Total		1,560	798		

During October 1979, at the request of the farmer, a three acre tomato field was surveyed at Veswaswarapura in Bangalore district. 135 parasitised larvae and 375 adult flies (mated females) were released in this field during October and November, 1979. Two months later i.e., on 24-1-80 from a tomato field which is about 1 km. away from the first field, 29 active *Heliothis* larvae were collected for observations. No releases were made in this field earlier. Seven of the 29 larvae were found parasitised and a total of 16 flies emerged in the laboratory. They were identified as *Eucelatoria* sp. by Dr. H. NAGARAJA, Entomologist, Commonwealth Institute of Biological Control, Indian Station, Bangalore.

Seventy mated females of *Eucelatoria* were released in a 5 acre tomato field on 22-2-1980 at Gulakmale in Bangalore district. A fortnight later i. e., 6-3-1980 twelve active *Heliothis* larvae were collected from an adjacent field and kept for observation in the laboratory. One *Eucelatoria* adult has emerged from this lot.

During March 1979, 54 *Heliothis* larvae were parasitised and released in a tomato field at G K V K Cross near Bangalore Subsequently during December 1979, several parasitised larvae which yielded *Eucelatoria* flies were collected by the Commonwealth Institute of Biological Control from Jakkur village, about 5 km from G K V K Cross (Personal discussion with Dr. H. NAGARAJA, and Commonwealth Institute of Biological Control, 1980).

All the above four instances show that *Eucelatoria* sp. nr. *armigera* obtained from the U S A is able to survive under the conditions prevailing in and around Bangalore. If the establishment proves to be permanent, it is conceivable that effective control of the pest will be obtained.

Acknowledgements: The authors are grateful to Dr. K. D. PAHARIA, Plant Protection Adviser to the Government of India for encouragement and all the facilities provided; to Dr. T. SANKARAN, Entomologist-in-charge, Commonwealth Institute of Biological Control, Indian Station, Bangalore for supplying a nucleus culture of the *Eucelatoria* sp. nr. *armigera* (COQ.); to Dr. H. NAGARAJA, Entomologist, CIBC, Bangalore for identifying the parasite and other staff members of Central Biological Control Station, Bangalore for technical help.

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REPORTS AND NEW RECORDS

OCCURRENCE OF THE BAGWORM, *PTEROMA PLAGIOPHLEPS* HAMPSON (LEPIDOPTERA, PSYCHIDAE) AS A PEST OF THE TREE, *ALBIZIA FALCATARIA* IN KERALA, INDIA

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(*Received 25 September 1980*)

The psychid *Pteroma plagiophleps* Hampson, known as a minor pest of tamarind in India, is recorded for the first time as a pest of *Albizia falcataria*, a fast growing tree species introduced from Moluccas. The larvae feed on leaves and outer bark of stem and build up enormously in numbers causing extensive defoliation.

(Key words: bagworm, psychidae, forest plantation, *Pteroma plagiophleps, Albizia falcataria)*

The bagworm, *Pteroma plagiophleps* Hampson (Lepidoptera, Psychidae) first recorded from Sri Lanka and described by HAMPSON (1892) under the genus *Acanthopsyche*, subgenus *Pteroma*, is known to occur in India as a pest of the tamarind tree, *Tamarindus indica* (AYYAR, 1940). It is considered to be only an occasional pest of minor importance on tamarind and has not been recorded previously on other hosts. In April 1977, an infestation of this insect was noticed in a 3-year old plantation of *Albizia falcataria* (LINN.) FOSB. (Syn. *A. falcata* (LINN.) BACK; *A. moluccana* MIQ.) (Mimosaceae) raised by the Kerala Forest Department at Vazhachal about 40 km east of Chalakudy (Trichur District). *A. falcataria* is a fast-growing tree species native to the Moluccas (FAO, 1975). In India, plantations of this species are still in the experimental stage (GHOSH, 1977). Severe infestation was noticed in two patches covering about 5 ha of a 20 ha plantation. In these patches, defoliation was almost total and the area presented a fire-burnt look from a distance. The larvae feed mainly on the abaxial surface of the leaflets; damaged leaves wither and fall off. They also feed, especially the older larvae, on the outer bark of the main stem and branches. Pupation occurs on the stem and the pupal bags remain suspended on silken threads from the branches. In the heavily defoliated area, thousands of pupae could be seen on each branch. Only small numbers of the insect were present in other parts of the plantation.

This is the first record of *Pteroma plagiophleps* as a pest of *Albizia falcataria*. It is recognized as a serious pest and is likely to become a limiting factor for successful raising of a *A. falcataria* plantations in Kerala. A closely related species of bagworm, *Brachycyttarus subteralbatus* HAMP. Syn. *Acanthopsyche subteralbata* HAMP.) is known to defoliate *Albizia* spp. in Sri Lanka (BEESON, 1941), but its status as a pest and the species of *Albizia* attacked are not known. An unidentified species of *Pteroma* with differs from *P. plagiophleps* in the wing venation was reported previously from Kerala, on pomegranate (AYYAR, 1944).

Acknowledgement: We are thankful to Dr. J. D. BRADLEY, Commonwealth institute of Entomology for identification of the insect.

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ON THE OCCURRENCE OF *PULVINARIA PSIDII* MASKELL (COCCDIAE : HEMIPTERA) AS A PEST OF CLOVE

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(Received 4 October 1980)

Clove *(Syzygium aromaticum)* was found to be infested by *Pulvinaria psidii* during January-February 1980 in Trivandrum, Kerala State. The scale insect was found clustered of the under-surface of leaves. As a result of its feeding the points of feeding on the leaves became yellowish and there was a general discolouration of the leaves This was the first time *P. psidii* was found infesting clove. The infestation could be controlled with 0.05 per cent monocrotophos spray. The other plants serving as host plants of the insect were guava, citrus, litchi, mango and sapota (NAIR 1975) and *Eugenea jambosa* (COCKERELL & ROBINSON, 1915.)

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D. N. RAYCHAUDHURI
(1924—1981)

The scientific community in India, especially the entomologists, sustained a great loss on the 1st of May, 1981 in the passing away of Prof. D. N. Raychaudhuri, at his residence in South Calcutta, following a brief illness. To those interested in aphid studies in the world at large and to *Entomon* the sad and sudden demise of Prof. Raychaudhuri was indeed an immediate and irreparable loss.

Prof. Raychaudhuri was born on the 15th of November, 1924 in Calcutta. He had his education in his home town. After graduating in 1947 he served on the faculty of various colleges in Calcutta. He subsequently joined the University of Calcutta in 1961 and was on the faculty of the Department of Zoology till his premature death. Prof. Raychaudhuri was also the Chairman of the Department for a term.

Aphids attracted the attention of Prof. Raychaudhuri in the early 1950's and he was always an active student of this group. He was awarded the D. Sc.

degree in 1956 by the University of Leiden, The Netherlands, for his excellent studies concerning *The Revision of Greenidea and related genera* of Aphids. Prof. Raychaudhuri visited other centres of learning like the British Museum (Natural History) for the study of aphid systematics and the University of Nottingham and University of Bristol for the study of Insect Biology and Agricultural Entomology. He has also visited France, Italy, Holland, West Germany and Italy. Recently he visited Japan and delivered lectures in the Hokkaido University. The University of Kerala had invited him to be a visiting Professor for a short term in the Department of Zoology.

The research interests of Professor Raychaudhuri extended beyond the study of aphids to soil mites, insect neurosecretion, physiology and pathology. He trained a number of students in these disciplines and since 1967 about 40 students took their doctorate under his guidance. He has also an impressive record as an author with about 200 papers to his credit. Recently he edited the monograph—*Aphids of North-east India and Bhutan* published by the Zoological Society, Calcutta. He has been serving as an expert in several committees at the state and National level. He was on the editorial Committee of *Oriential Insects*. Prof. Raychaudhuri was intimately associated with *Entomon* and was on its Editorial Board from the very beginning of its publication. He was the Vice-President of the Indian Society of Soil Biology and Ecology.

Prof. Raychaudhuri organised the first Oriental Entomology Symposium in Calcutta in 1973, which was a unique event in the History of Entomology in India.

An unassuming and kind hearted gentleman, the late Prof. Raychaudhuri leaves behind, his wife, a daughter and a son.

N. R. Prabhoo

Reg. No. R. N. 29386 / 76

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Articles in journals: NAYAR, K. K. (1958), Studies on the neurosecretory system of *Iphita*. V. Endocrine basis of oviposition in female. *Proc. Indian Acad. Sci.*, **47B** : 234—251.

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